THE
CORALLINACEAE OF THE SIBOGA-EXPEDITION

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BY

A. WEBER–VAN BOSSE AND M. FOSLIE
Eerbeek Trondhjem

With XVI plates and 34 textfigures

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INTRODUCTION

BY

A. WEBER—VAN BOSSE.

No algae excite such general interest as calcareous algae. They are not only a delight and at the same time a constant puzzle to botanists, but also to geologists who are compelled to study them, for they meet them in various formations in layers of enormous thickness, for instance in the Scandinavian Baltic-silurian district; near Syracuse, where the renowned Latomiae are quarries in old Lithothamnion-banks; in the "Leithakalke" near Vienna or in the Dolomites. Zoologists again finding them in a living state, will fain ask what these brilliant coloured organisms are, that are often found in such enormous masses in tropical, temperate and arctic regions; either branched and forming knolls perhaps as big as or bigger than a man's fist, and giving shelter to innumerable animals; or crustlike, and covering corals, stones and other algae with thin or thick crusts.

The study of calcareous algae is, like all algological study, one of the younger branches of botanical science. In 1816 LAMARCK [1]) in his renowned book "Histoire des Animaux sans

1) LAMARCK. Hist. nat. d. Animaux sans vertèbres. Paris 1816, t. II, p. 203.

vertèbres", created the name of *Nullipores* for the "millépores avec pores polypifères peu ou point apparens", in opposition to "millépores avec pores polypifères toujours apparens". This name *Nullipore* has outlived its time and cannot be maintained. PHILIPPI [1]) first and afterwards UNGER [2]) have shown in a clear and convincing manner that a great number of so called *Nullipores* recent and fossil are Lithothamnia. GÜMBEL [3]) in 1871 divided the *Nullipores* into "die sog. *Nulliporen* aus dem Pflanzenreiche: *Lithothamnium*" and "die *Nulliporen* des Thierreichs: *Dactyloporidae*".

The *Dactyloporidae* which GÜMBEL still considered as belonging to the animal kingdom have since been recognized by MUNIER-CHALMAS [4]) as calcareous algae belonging to the group of the *Dasycladiaceae*. Old fossil forms of this family are known according to STOLLEY [5]) from the Scandinavian Baltic-Silurian, and recent representatives live in the warmer temperate and tropical seas under the generic names of *Cymopolia*, *Neomeris*, *Acetabularia*, etc.

If now these two groups the *Lithothamnia* in the broad sense and the *Dactyloporidae (Dasycladiaceae)* are taken out of the old group of the *Nullipores*, one feels inclined to ask, do there still remain any *Nullipores*?

On the reefs in the tropical seas calcareous algae are found in great quantities: *Halimeda*, *Galaxaura*, *Liagora*, *Peyssonelia* — this last one remarkable because it sometimes imitates incrusting *Lithothamnia* — and many others, but none of these will be considered a *Nullipore* by botanists. A. C. SEWARD [6]) speaking of *Nullipores* says: "the genus *Nullipore* has been used in an extremely wide sense embracing organisms which are for the most part members of the vegetable kingdom but including others that must still be retained as animals". This shows clearly that the genus of the *Nullipores* has in fact been broken up into various families of which none can pretend to the name of *Nullipore*.

Still the old name persists; I was puzzled several times, while reading the beautiful illustrated account of Prof. AGASSIZ [7]) on the coral reefs, to understand what the author meant by *Nullipores*. On page 73 for instance we read "*Nullipores* and other calcareous algae" on page 229 "large blocks of algae and *Nullipores*". After all that I have seen of reefs, I believe that all these bright-coloured *Nullipores* are algae, belonging to very different families and genera. The old name brings only confusion to a botanical mind; it can only be used in a very broad sense to indicate all the marine vegetable organisms, which contain chalk in their membranes, thus including all calcareous algae.

The Siboga Expedition, sent out for the exploration of the deep-sea basins and the marine fauna and flora not only of these but also of less deep and of shallow waters in the Malay Archipelago, visited a great number of islands during her cruise of a year. Whenever

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1) PHILIPPI. Beweis dass die Nulliporen Pflanzen sind. WIEGMANN's Archiv 1837, p. 387.

2) UNGER. Zur näheren Kenntniss des Leithakalkes. Denkschr. d. K. Akad. d. Wissensch. Wien 1858.

3) GÜMBEL. Die sog. Nulliporen (Lithothamnium und Dactylopora). Abh. d. K. Bay. Akad. d. Wissensch. 1874, Bd. XI.

4) MUNIER-CHALMAS. Observ. sur les Alg. calc. appartenant au groupe des Siphonées verticill. (Dasycladées Harv.). Comptes rend. Acad. sc. 1877.

5) STOLLEY. Die Silurische Algenfacies und ihre Verbreit. im Skand. balt.-sil. Gebiet. Schrift d. Naturw. Ver. für Schleswig-Holstein 1898, XI, p. 109.

6) SEWARD. Algae as Rock-building Organisms. Sc. Progress 1894, vol. II, p. 18.

7) A. AGASSIZ. The coral reefs of the Trop. Pacific. Cambridge U. S. A. 1903.

there was an opportunity her staff would go ashore or land on the numerous reefs that surround the islands to collect animals and plants. Great was my astonishment to find *Lithothamnia* on almost every reef; in not less than 55 stations did we gather these organisms in greater or smaller quantities, indeed almost on every occasion, where marine algae could be gathered. This impressed me much, as up to the time of the Siboga Expedition little was known about *Lithothamnia* from the Malay Archipelago. VON MARTENS [1]) in his standard-work "Die Tange von Ost-Asien", attributed our slight knowledge of them to the neglect by botanists to collect them. I was well acquainted with the fact that DARWIN [2]) had mentioned three *Nullipores* of the Keeling-Atoll, that HEYDRICH [3]) had lately described four new species from New-Guinea, and that MARTIN [4]) had described *Lithothamnium Rosenbergi* from the Tertiary of Timor and New-Guinea, still I was not prepared to meet with such masses of these algae nor above all to find them almost everywhere.

I am sorry to say that two geological papers had escaped my notice, for as early as 1891 WALTHER [5]) had described subfossil banks of *Lithothamnia* from the Palk Straits and in 1898 — the year we left Europe — W. STANLEY GARDINER [6]) published two papers, one on the coral reefs of Funafuti, the other on the building of Atolls. In these papers he mentions several times the presence of great numbers of *Nullipores* recent and fossil on the coral reefs of Funafuti, and their presence everywhere in great heaped up masses impressed him so strongly that he writes in the latter paper p. 121: "The chief organisms, so far as I have seen, engaged in building up coral reefs are massive and incrusting *Nullipores*".

The results of the Siboga confirming, as they do, all those of previous and of simultaneous investigators [7]) deserve special notice as throwing some light on the conditions under which *Lithothamnia* grow. *Lithothamnia*, as everybody knows, belong to the family of the *Corallinaceae*. ARESCHOUG [8]) united them with *Hapalidium*, *Melobesia* and *Mastophora* in the group of the *Melobesieae* in opposition to the *Corallineae* (verae) to which he referred *Amphiroa*, *Cheilosporum*, *Arthrocardia*, *Jania* and *Corallina*. The inarticulated fronds of the *Melobesieae* and the articulated fronds of the *Corallineae* are still a good character, whereby to distinguish the two groups, although that of the *Melobesieae* has undergone many changes since ARESCHOUG's Monograph appeared, as will be seen in the following pages by FOSLIE.

The Siboga Expedition found *Lithothamnia*, as already stated, at 55 stations; their favourite habitats as a rule being where a strong current was running. If a strong tidal or other current swept along the Siboga, while she lay at anchor, this was enough to induce us

1) G. VON MARTENS. Die Tange von Ost-Asien. 1866. p. 107.

2) CH. DARWIN. A naturalist's voyage round the world. 1860, p. 498.

3) F. HEYDRICH. Beitr. zur Kenntn. der Algenflora von Kaiser Wilhelm's Land (Deutsch Neu-Guinea). Ber. d. D. Bot. Gesellsch. 1892, p. 483. — Beitr. z. Kenntn. d. Algenflora von Ost-Asien. Hedwigia 1894, p. 299. — Neue Kalkalgen v. D. Neu-Guinea. Biblioth. botanica 1897.

4) K. MARTIN. Samml. d. Geol. Mus. in Leiden 1881. Sedimente Timors p. 1. Tertiär von Neu-Guinea p. 65.

5) P. J. WALTHER. Die Adamsbrücke u. d. Korallenriffe d. Palkstrasse. Ergänz. Heft Pet. Mitth. 1891. — Lithogenesis d. Gegenwart. Jena 1893.

6) W. STANLEY GARDINER. The coral reefs of Funafuti, Rotuma and Fiji. Proc. Cambridge Phil. Soc. IX, 1898. The building of Atolls Proc. Intern. Congress Zoology 1898.

7) AGASSIZ found "Nullipores" or huge masses of calcareous algae on almost every reef in the Pacific Ocean which he visited during the winter 1899—1900.

8) J. E. ARESCHOUG. Corallineae in AGARDH's Genera et Species Floridearum 1851, p. 506.

to throw out a dredge and very often success would crown our endeavours and the dredge would bring up *Lithothamnia*. We kept a small, strong dredge for this work, for the chances of losing our net and even the whole dredge were often great. The *Lithothamnia* appeared to thrive best in from 10—30 m. but we as often found them on the reefs near to or below low-water mark, though seldom in great quantities; and again several little bits, too small for determination or barren, came up at various times with the lead from a depth of 75, 83, 94 and 120 m.

Near the coast of Haingsisi, an island near the S.W. point of Timor, the Siboga anchored

Lithothamnion-bank of Haingsisi.

twice (Stat. 60 & 303); the second time good-luck favoured us, it was springtide, the water sank very low and we could observe that the whole reef, which stretched from the shore out into the sea, consisted chiefly of *Lithothamnion erubescens* f. *Haingsisiana*. It was remarkable that the branching knolls remained quite dry during several hours of the day, exposed to the glare of the tropical sun and that this seemed not to injure them. This shows clearly that at least some species of this genus do not fear the rays of the sun, as others appear to do in the Gulf of Naples. Along the coast of arctic Norway species growing in shallow water, always partly lose their colour in summer — according to a communication in a letter from FOSLIE —

but this is owing to the permanent light, day and night, that reigns in these regions during the summer months. Even outside the polar circle as far south as Trondhjem the influence of the northern summer is visible on the *Lithothamnia*. On the south coast of Norway, where FOSLIE also collected *Lithothamnia*, they are as a rule much darker.

The reef of Haingsisi was literally covered with knolls of *L. erubescens*, as the two text-figures show. The knolls were of very different size; we found little ones only 1—2 cm. in diameter and other big ones that measured 9 cm. Often two or more knolls had grown together and formed one big knoll; the living ones were red all round, the dead and the

Lithothamnion-bank of Haingsisi.

dying ones were totally or partially white. Other species and genera as *Lithothamnion australe*, *Lithophyllum Okamurai* and *Goniolithon Reinboldi* were also to be found, but they were numerically of no importance compared with the ubiquitous *L. erubescens*.

This *Lithothamnion*-bank struck me because it is such a unique sight to see the ground, as far as the eye can reach, covered by the pretty beautifully pink-coloured knolls, which are heaped up so close together that, while walking, one crushes them continually making a peculiar noise as of broken china. We encountered however other and perhaps more instructive *Lithothamnion*-banks during our voyage.

Near Lumu-Lumu Island, Stat. 78, a coral island that rises to the surface of the sea from the Borneo-bank in the Makassar Straits, the Siboga anchored for a couple of days. During our stay on the Borneo bank our little dredge was often thrown out behind the ship and hauled up at her forecastle and every time it came up filled with various species of *Lithothamnion*, *Goniolithon Reinboldi* coming up oftenest. All along the east-side of Borneo and in the Sulu Archipelago we met *Lithothamnia* in such quantities, that they formed a conspicuous character of the reefs. It was also here that I found for the first time *Archaeolithothamnion Sibogae*; its thick branches and beautiful soft pink colour were fascinating to the eye, while the knowledge, that representatives of this genus were described by ROTHPLETZ from the Jurassic and Pliocene periods, made it doubly interesting to the mind.

In shallow channels near Tual, Stat. 258, of Low-Key Island the dredge was filled with *Lithothamnion australe* f. *tualensis*. We were at work for hours with the steam-launch and constantly the dredge brought up *Lithothamnia* even to the vexation of our zoologists. For though *Lithothamnia* will give shelter as a rule to a great number of quite different animals, which adapt themselves outwardly in form and colour in a striking manner to the plants on which they live, this is not always the case. The *Lithothamnia* of Tual were not favourable to the maintenance of animal life, being small with widely spreading branches and thus affording but a bad shelter to snails, worms, star-fish and other animals.

The most remarkable bank was one south of the Island Saleyer, Stat. 66, mentioned on the charts as a "coral bank" and extending between the islands of Bahuluwang and Tambolungan. The Siboga had vainly tried to find a good anchorage on the east-side of Saleyer; the night advanced rapidly and therefore Commander TYDEMAN resolved to anchor for the night on the above named coral-bank, where he was sure to find from 8—10 m. water. How great was our astonishment the next morning when coming on deck, we saw a distinct red colour at the bottom of the sea regularly interrupted by narrow white bands. It was no coral bank on which we were lying but an enormous bank of *Lithothamnia*, that gave a red colour to the bottom of the sea, and the white bands we remarked consisted of heaped up dead joints of *Halimeda*.

WEBER [1]) examined the whole bank and his view of *Lithothamnion*-banks, the conditions under which they develop themselves and expecially of this particular bank may well be recapitulated here.

For the development of *Lithothamnia* the bottom upon which the roundish knolls grow must be more or less flat. A current must be running over it, which turns the knolls lightly over, for the knolls want light and sea-water on every side or they would soon lose their red colour, which means death to them. We observed this on the bank of Haingsisi where half-buried knolls were quite white on their underside. But the current must not be too strong. Where *Lithothamnia* throve best many tiny *Florideae* grow on them and this would be impossible if the current turned the knolls roughly over. The structure of this peculiar bank near Saleyer WEBER explains as follows:

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1) MAX WEBER. Introduction et Description de l'Expédition du Siboga 1902, p. 38.

"Between the islands of Bahuluwang and Tambolungan our bank extends in a direction from North to South covered by a layer of water averaging from 6 to 9 metres deep; but towards the West and East of the bank the layer of water deepens fairly rapidly, attaining a depth of 10, 14 to 18 metres, becoming at last very deep. On this bank *Lithothamnia* live in great abundance; living corals are entirely wanting. The net, in fact, only brought up scanty and dead fragments, which the current had clearly carried there after detaching them from neighbouring coastal reefs. The force of the current is great. During the ebb it sets west, while the flood tide sets east. If the bank is bare of corals — which is seldom the case in the Archipelago — this is due to the current which, carrying along sand and débris of *Halimeda*, covers up the corals that are trying to establish themselves there and smothers them out of existence. This is not the fate of the *Lithothamnia*. As we have said, the current rolls them sometimes in one way sometimes in another according as it is running East or West, flood or ebb. In places where the play of forces is suitably balanced between the strength of the current, the weight of the nodules of *Lithothamnia* and the weight and mass of the detritus, the nodules remain free and uncovered and are able to form a bank. But in places where local accumulations of detritus are formed, in the same direction as the current, those bands of which we have spoken appear; these are less favourable to the development of *Lithothamnia* and become less and less so in proportion as they grow more accentuated".

In Arctic seas FOSLIE [1]) tells us, that *Lithothamnion*-banks often consist of only one species. Near Nowaja-Zemlya and Spitsbergen *Lithothamnion glaciale* will cover the bottom for several miles and on the coast of Iceland and northern coast of Norway *Lithothamnion Ungeri* will occur in masses. So also *Lithothamnion investiens*, a species nearly related to the former, covers in certain places on the north-coast of Norway the bottom for several miles. In the Malay Archipelago it appeared to us, that one or other species usually was predominant but other species would not be entirely lacking, and incrusting forms can almost always be found, when attentively searched for. For the *Lithothamnia*, besides contributing greatly to the bulk of a reef or bank by their branching species, will also play an active part in the building up of a reef by their incrusting species, which grow over shells, corals or other *Lithothamnia*, cementing all these together into one solid mass. The value of this cementing cannot be over-estimated on a reef, where the waves of the sea are continually washing off the looselying masses.

A most dangerous enemy to *Lithothamnia* is another family of algae: the boring algae. These algae were first made known by BORNET and FLAHAULT [2]). They belong as a rule to filamentous blue, green or even red algae. The study of these plants has as yet only been begun and their universal distribution and their power of disintegrating even rocks, will become more and more recognized.

Here and there in literature I have met with the expression "green *Lithothamnia*". I do not believe that there exists one single green species of *Lithothamnion*. If knolls or crusts of these plants are green, this is due to boring algae, which are found according to my experience

1) M. FOSLIE. The Lithothamnia of the Laccadive and Maldive Islands. Fauna and Geogr. of the Mald. and Lacc. Archipelagoes. vol. II, part. 4.

2) BORNET et FLAHAULT. Sur quelques plantes vivant dans le test calcaire des Mollusques. Bull. Soc. bot. de France. t. XXXVI.

in great quantities in all *Lithothamnia* of the tropical seas. And not only *Lithothamnia* but also corals have to suffer from these algae. DUERDEN [1]) writing about algae as coral disintegrating agents says p. 326: "the surface of many corals, even when covered with the polypal tissue is strongly green in colour .... (due) to the presence of green filamentous algae".

Wonderful is life on a coral reef and the various agents now building up and then destroying again what scarcely was developed, will ever afford a tempting object of study to Naturalists.

In the above quoted paper on the *Lithothamnia* of the Laccadive and Maldive Islands FOSLIE observes that "the *Lithothamnia* of the Tropics have been rather disregarded". In latter years, thanks to several collections that were sent for investigation either to FOSLIE or to HEYDRICH our knowledge of these plants has much increased and the collections of the Siboga, to which were added some specimens brought home by the Dutch New-Guinea Expedition, will help to give us a fairly good idea of the distribution of *Lithothamnia* in the Indian Seas. FOSLIE has described in the following pages 32 species of *Lithothamnion* and other genera, belonging to the group of the *Melobesieae* Aresch.; amongst these seven are new to science, and three, which I had studied while still on board H. M. Siboga, were published shortly after my return, in our joint names, and here I should like to say, how happy I am to have secured for the collections of the Siboga the valuable collaboration of Mr. FOSLIE. His extensive knowledge of all existing *Lithothamnia* gives us hope, that he will bring order into this most confusing group.

It was first understood between us, that Mr. FOSLIE should work out the incrusting and I the branching *Lithothamnia*, but I soon discovered that I should be most grateful if he would undertake the naming of them all. The *Corallineae verae*, of which the Siboga material contained several genera and species were to be worked out by me alone and the paper in which both groups *Melobesieae* Aresch. and *Corellineae verae* were treated, appear under our joint names.

The *Corallineae verae*: *Amphiroa*, *Cheilosporum*, *Jania* and *Corallina*, slender plants as they may be, are very active reef-builders, indeed, taking their smallness into account, it is astonishing to observe how much sand may be kept together by their tiny branches. They illustrate often in a wonderful manner how true the words of WALTHER are: "Das Wesen der Riffbildung beruht im Sandfangen".

Corallineae verae were gathered by the Siboga to a depth of 36 m. On the Borneo bank beautiful, long-creeping specimens of *Cheilosporum spectabile* Harv. were found. Large squarrose *Amphiroae* were abundant along the south-east coast of Timor, indeed almost every reef yielded one or another species of this genus. Still I could not detect more than a single, new species among my collection. The French investigators who explored the eastern part of the Archipelago during the beginning of the nineteenth century had already gathered them all, and they were described by LAMOUROUX.

I would like to express here my sincere thanks to Prof. LIGNIER of Caen for lending me so liberally the *Amphiroae* out of LAMOUROUX's Herbarium.

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1) DUERDEN. Algae as Coral disintegrating Agents. Bull. Amer. Mus. of Nat. Hist. 1902, XVI.

But if the study of the *Amphiroae* showed clearly that only one new species was to be looked for amongst my material, at least this study led me to a careful investigation of the whole group, which had to be worked out afresh. How and why this was done will be explained in that part of the paper that treats of the *Corallineae verae*.

I should like also to express my thanks to Prof. ROTHPLETZ of München and to Prof. MARTIN of Leiden, who both gave a large collection of fossil slides containing *Corallinaceae* to Mr. FOSLIE and me for investigation. In the collection of Prof. MARTIN I detected a fossil *Amphiroa* from the Tertiary of Celebes and a fossil *Jania* from a more recent stratum at Ambon, and in a slide from the Tertiary of New-Guinea that I owed to the kindness of Prof. WICHMANN of Utrecht, I found another species of *Amphiroa*.

To all those, who gave me good advice and helped me on, though I don't name them here, I feel heartily indebted and especially so to my kind friends Mr. and Mrs. GEPP who looked over this paper and improved my English.

I.

LITHOTHAMNIONEAE, MELOBESIEAE, MASTOPHOREAE

BY

M. FOSLIE.

With plate I—XIII.

I. Lithothamnioneae Fosl. [1]).

Lithothamnion Phil. (Fosl. emend.).

a. Crustacea [2]).

1. *Lithothamnion siamense* Fosl.

Corall. in Schmidt, Fl. Koh Chang II, p. 19; excl. f. simulans.

f. *typica*. Fig. 3; Pl. I, fig. 1—2.

Lithothamnion siamense f. minuta Fosl. l. c.

f. *pseudoramosa* Fosl. mscr. Pl. I, fig. 3—9.

The crust forming short branch-like excrescences, mainly by covering up undissolved conceptacles, other species or extraneous objects, and often less clinging to the substratum than in the typical form.

Stat. 49ª.	Sapeh Strait, Sumbawa.	69 m. Coral and shells.
Stat. 64.	Kambaragi Bay, Tanah Djampeah.	Up to 32 m. Coral, coral sand.
Stat. 109.	Pulu-Tongkil, Sulu Archipelago.	13 m. Lithothamnion bottom.
Stat. 125.	Sawan, Siau Island.	27 m. Stone and some Lithothamnion.
Stat. 234.	Nalahia Bay, Nusa-Laut Island.	46 m. Stony.
Stat. 258.	Tual, Kei Islands.	5—20 m. Lithothamnion, sand and coral.

1) In Det Kgl. Norske Videnskab. Selsk. Skrifter 1902, Aarsberetning (Trondhjem 1903) I have divided the Corallinaceae in the following sections, provisionally without particular argument: Chaetolithoneae: *Chaetolithon*; Lithothamnioneae: *Phymatolithon*, *Clathromorphum*, *Lithothamnion*, *Archaeolithothamnion*; Schmitzielleae: *Schmitziella*; Choreonemeae: *Choreonema*; Melobesieae: *Goniolithon*, *Melobesia*, *Dermatolithon*, *Lithophyllum*; Mastophoreae: *Mastophora*; Corallineae: *Amphiroa*, *Cheilosporum*, *Corallina*.

2) In Norw. Lithoth. and Rev. Syst. Surv. Melob. I divided *Lithothamnion* into Innata and Evanida. Instead of this I here propose Crustacea, Subramosa and Ramosa.

As remarked l. c., this is one of the most delicate species of the genus *Lithothamnion* attached to hard objects. It sticks to different other calcareous algae, especially dead or stunted ones, calcareous sediment, corals, dead shells of molluscs, or occasionally stones. When the plant occurs on a level, or fairly level, substratum, the crust is smooth and generally has a thickness of 30—60 μ. In this case it clings rather closely and often firmly to the substratum (Pl. I, fig. 1—2). Frequently, however, new crusts will be formed, one above the other, or the primary crust will develop secondary incrustments. Such a complex of crusts may attain a thickness of up to 300 μ. The species is apt to being overgrown by other calcareous algae, and is often itself attached to other species. A section of the plant with its substratum will, therefore, now and then exhibit layers of two or several species growing one above the other or even alternating with lower animals, e. g. Bryozoa.

If the substratum is rough, or if foreign bodies have attached themselves to the primary crust, the surface of the plant finally becomes more or less uneven. The formation of new crusts on fertile specimens, expanding over undissolved conceptacles of sporangia or cystocarps, or the occurrence of the plant on other crustlike species which are sparingly branched, e. g. stunted *Lithothamnion fruticulosum* f. *clavulata*, gives rise to the form which I have named f. *pseudoramosa*. The form is certainly but slightly differentiated and ought perhaps not to be kept distinct. However, as it is externally often rather diverging from f. *typica*, I classify it as a separate form (Pl. I, fig. 3—9). Besides it does not appear to adhere so intimately to the substratum, but shows a tendency to partly detaching itself from the latter.

As regards the structure of the species, vertical sections show that the hypothallium [1]) frequently consists of a few layers of cells whose lower anticlines are often but slightly converging to the substratum, sometimes not converging at all, and apparently never marked coaxial. The cells are elongated and may be up to about 25 μ. long, though they rarely exceed 12—18 μ. The perithallium, issuing from the hypothallium and as a rule taintly developed, is formed by cells which are partly roundish, partly square, 6—10 μ. in diameter, often, however, a little elongated, with the longer diameter now in horizontal, now (and more frequently) in vertical direction, in the latter case being exceptionally up to 18 μ. long and 10 μ. broad; fig. 3 [2]).

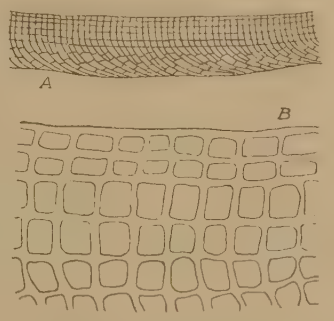

Fig. 3.
Lithothamnion siamense Fosl. f. *typica*.
A. Vertical section of the crust; × 72.
B. Part of the perithallic layer in vertical section; × 390.

The reproductive organs hitherto known are sporangia and cystocarps which occur on different individuals. The former are subprominent or almost superficial, 300—400 μ. in diameter, when seen from above, at first convex, afterwards more or less flattened, with a thin roof, perforated

1) The two kinds of tissue which form the thallus in most of the algae in question were indicated by SOLMS-LAUBACH as *Markstrang* and *Rinde*. ARESCHOUG used for the former the denomination of *hypothallium*, and for the latter ROTHPLETZ proposed the name of *perithallium*. I have adopted the latter name in the same sense. As to the former, I also use the term of hypothallium for the basal or rhizoidal layer, composed of rows more or less bent or coaxial in a number of crustlike forms. If this tissue consists of only one basal cell-row, as the case is in some other forms, I simply name it the basal cells or one-layered hypothallium. In attached, branching forms there is frequently some difference in size and sometimes even in shape between the said hypothallium in the crustlike part of the plant and the inner layers of radiating tissue in the branches. In describing the structure I therefore name the latter *medullary hypothallium*.

2) All the figures showing the structure of the species are from undecalcified sections which have been made thin by grinding.

by about 40 delicate muciferous canals. The roof finally falls off, and dissolved conceptacles only leave small elevated edges, or a scar more or les distinguishable. The four-parted sporangia are 60—70 μ. long, and 25—30 μ. broad. The conceptacles of cystocarps are almost superficial, conical, sometimes however rather low, abruptly passing into a very short and thin tip, which soon falls away, 350—450 μ. in diameter, when seen from above. Antheridia are unknown.

The typical form of the species in sterile stage is easily confounded with young Squamariaceae, and is sometimes hardly distinguishable from young specimens of *Lithothamnion simulans*. The form *pseudoramosa* is in habit approaching young and stunted specimens ot *Lithothamnion fruticulosum* f. *clavulata*, for which it is easily mistaken, sometimes being hardly distinguishable from it also as to structure. It is of no infrequent occurrence that it covers specimens apparently belonging to the form mentioned.

Specimens of the present species having been collected in April, May, July and December are sparingly provided with cystocarps and sporangia. In the Gulf of Siam the species bears these organs in the month of February.

Occurrence: On the whole this species occurs rather scarcely. The comparatively greatest number has been found at the stations 49ª, 64, 258. The species mostly has been found associated with *Lithothamnion fruticulosum* and *Lithothamnion australe*, but almost always it shares the substratum also with stunted specimens of other calcareous algae and a series of lower animals.

Area: North Pacific: The Gulf of Siam.

2. *Lithothamnion bandanum* Fosl. mscr. Fig. 4; Pl. I, fig. 10.

Thallus crustlike, up to 0,5 mm. thick, closely clinging to the substratum. Conceptacles of sporangia subprominent, 250—450 μ. in diameter.

Stat. 240. Banda. Lithothamnion bank in 18—36 m.

Of this species only a single specimen is known. It is 1 cm. in diameter, and forms a crust, up to about 0,5 cm. thick round the substratum, whose form it assumes. Some wartlike excrescences seem only to be owing to the form of the substratum, and it is questionable whether such ones really are developed from the crust at all (Pl. I, fig. 10).

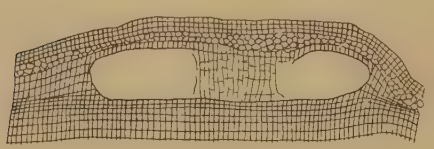

Fig. 4. *Lithothamnion bandanum* Fosl. Part of the perithallium in vertical section, with transversaly cut cells of a feeble hypothallic layer above the grown-in conceptacles; × 72.

A vertical section exhibits a faintly developed hypothallium, formed by rows of cells whose lower anticlines are but very sligthly converging to the substratum. The cells attain a length of 12—20 μ., and a breadth of up to 10 μ. — The cells of the perithallium are rather irregular and have often thick walls. They are partly roundish, partly (and mostly) vertically elongated, 7—15 or sometimes up to 18 μ. long, and 6—8 or seldom up to 10 μ. broad. There is no distinct stratification to be seen in a section, but new hypothallic layers here and there are formed over conceptacles or small extraneous objects (Fig. 4).

The conceptacles of sporangia are at first convex, partly very slightly rising above the surface of the thallus, partly subprominent, finally fairly flattened, rather crowded in any part

of the crust, 250—450 μ. in diameter, when seen from above. Two or three conceptacles sometimes become confluent. The roof is intersected with about 30 muciferous canals. The conceptacles become overgrown and appear in great number in a section of the crust. A few ones examined were partly emptied, partly attacked by animals who had destroyed the sporangia. The specimen was picked up towards the end of November, therefore the plant is likely to bear mature sporangia by this time.

In habit this species on one hand approaches a little certain forms of *Lithothamnion Engelhartii*, and on the other hand *L. fumigatum*. It is however most closely allied to *L. maldivicum* both in habit and structure, but the conceptacles are much smaller, and as regards structure it mostly shows smaller and less thick-walled cells than the said species.

Occurrence: The only specimen met with was found among a number of stunted calcareous algae from the quoted station apparently belonging to *Lithothamnion fruticulosum*.

b. Subramosa.

3. *Lithothamnion fragilissimum* Fosl. mscr. Fig. 5; Pl. I, fig. 11—16.

Thallus crustlike or more or less leaf-like, 150—500 μ. thick, horizontally extended, partly attached, scantily and irregularly prolificating. Conceptacles of sporangia convex, but very little prominent, at length somewhat flattened, crowded, 350—450 μ. in diameter.

Stat. 78. Lumu-Lumu-shoal, Borneo-bank.
Stat. 81. Pulu Sebangkatan, Borneo-bank.
Stat. 234. Nalahia Bay, Nusa-Laut Island. Reef.

The plant occurs partly, and particularly when young, clinging rather closely to the substratum, partly, and most frequently, but loosely covering the latter, here and there attached to it. At lenght the greater part of the thallus gets free. It is 150—500 μ. thick, decreasing in thickness towards the margin, somewhat shining, rather brittle, but on the other hand of a rather hard consistency. Judging from a solitary almost entire specimen it is somewhat lobed (Pl. I, fig. 11). The species is scantily prolificating. The prolifications partly more or less cling to the primary crust, partly they are semi-circular and somewhat rising, or irregularly plicate, mainly when covering up extraneous objects. Besides it is often provided with small and irregular excrescences, which also are due to its covering up different objects. The plant is concentric zonate, distinctly so in the part turning downwards, in the part turning upwards indistinctly.

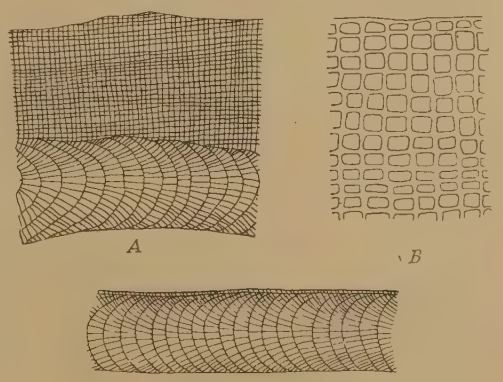

Fig. 5. *Lithothamnion fragilissimum* Fosl.
A. Vertical section towards the central part of the crust; × 72. *B*. Part of the perithallic layer in vertical section; × 390. *C*. Radial section near the margin; × 72.

As to the structure, a radial section of the crust shows a marked and rather vigorous coaxial hypothallium, which in the central parts of the crust frequently sends forth upwards rather long perithallic rows. On the contrary, in the peripherical portions the perithallium is very faint (Fig. 5 *C*). The

hypothallic cells are 18—28 μ. long and 7—14 μ. broad, partly with fairly thick walls, partly thin-walled. In the perithallic layer the cells are partly square or somewhat rounded, partly a little vertically or horizontally elongated, frequently 5—8 μ. in diameter, with rather thick walls, here and there however commonly elongated in vertical direction and up to about 12 μ. long, very seldom more except between crowded conceptacles of sporangia, where the cells may be somewhat longer. (Fig. 5).

The reproductive organs hitherto known are sporangia. The conceptacles are mostly densely crowded on different parts of the crust, sometimes partly confluent, and are in old specimens finally overgrown. They are not much prominent, with slightly convexed roof, at length somewhat flattened, circular or oblong in circumference, but often not sharply defined, 350—450 μ. in diameter, when seen from above. The roof is thin and intersected with 30—40 delicate muciferous canals. The sporangia are four-parted, about 80 μ. long und 30 μ. broad, with enduring partition walls between the former. The plant bears these organs in the months of June and November, but rather scantily.

The species comes nearest to *Lithothamnion Engelhartii* from the south coast of Australia. It is distinguished from the latter in habit particularly by a thallus more spread and more freely growing. Besides it is brittler. The conceptacles are a little larger and less sharply defined, and there is also some difference as to structure. Young or sterile specimens are, on the other hand, hardly distinguishable from *Lithothamnion simulans*.

Occurrence: This species seems to have been best developed at the station 81, from which, however, only a few specimens, more or less fragmentary, are in hand. From the station 78 only a small fragmentary crust has been brought home, together with *L. simulans*, and from the station 234 there is only one young specimen, accrete with two or three other species, among which a Squamariacea and perhaps a young *L. simulans*.

By the kindness of Professor K. MARTIN I have had the opportunity of examining some sections of fossil sediments from the Geological and Mineralogical Institut at Leyden, mainly from New Guinea. These sections include a great number of calcareous algae, among which two of the types of *Lithothamnion Rosenbergi* K. Mart. [1]). This species I classified in Rev. Syst. Surv. [2]) as *Archaeolithothamnion Rosenbergi* according to the description given by ROTHPLETZ in Foss. Kalkalg. [3]). Having afterwards been acquainted with the original description and the pictures of the species, I find it questionable, whether it includes any *Archaeolithothamnion* at all. At any rate it includes at least two species, one of which may be identical with *Lithothamnion fragilissimum*. Fig. 6 represents a reproduction of the pictures mentioned. Judging from

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1) K. MARTIN. Die Versteinerungsführenden Sedimente Timors. — Sammlungen des geolog. Reichsmuseums in Leiden. I, Heft 1 (1881), p. 12, t. III, fig. 6—7.

K. MARTIN. Eine Tertiaerformation von Neu-Guinea und benachbarten Inseln. l. c. Heft 2 (1881), p. 70.

2) M. FOSLIE. Revised Systematical Survey of the Melobesieae. — Det Kgl. Norske Vidensk. Selsk. Skrifter. 1900, n⁰ 5.

3) A. ROTHPLETZ. Fossile Kalkalgen aus den Familien der Codiaceen und Corallinaceen. — Zeitschr. d. Deutschen geolog. Gesellsch. Bd. XLIII, Heft 2 (1891), p. 295.

the description l. c., I think the fig. 6 *A* (the fig. 6 of the original) is to be looked upon as the proper type of the species. But of this one I have only seen the picture. To judge from the picture, the supposed sporangia are of another form than usually found with *Archaeolithothamnion*, but this may be owing to an accidental obliquity of the section. They are, however, according to the picture surrounded with a structureless mass, which seems to show that this part of the figure doesn't represent any calcareous alga, whereas the parts situated above and below are likely to be such ones. According to MARTIN l. c. the cells here are 10 μ. long and broad. In sections of fossil sediments with calcareous algae, as well as of recent forms of the latter, we will frequently observe that layers of crustlike calcareous algae occur alternating, occasionally even quite regularly, with certain species of lower animals. It is not improbable that fig. 6 *A* represents such a state of things. As a matter of course I don't venture to express any decided opinion, judging from the picture alone, and I therefore still subsume the species under *Archaeolithothamnion*.

Fig. 6. *Lithothamnion Rosenbergi* K. Mart. *A* × 50; *B* × 23; *C* × 32. (After MARTIN).

The form reproduced in fig. 6 *B* is found in section "123 Soëk v. Rosenberg (8)". It is "von dem Eilande Soëk im Geelvink-Busen, an der Nordküste von Neu-Guinea". — — "Unter den Organismen herrscht Lithothamnium hier so sehr vor, dass es geradezu gesteinbildend auftritt und man in Dünnschliffen ausser dieser Pflanze oft nur noch spärliche, die Zwischenräume ausfüllende Kalkspathkörnchen wahrnimmt" [1]). This form is no doubt to be referred to the group of calcareous algae which form thin crusts or foliaceous thallus like *Lithothamnion lichenoides*, *L. fragilissimum* and other species. The thickness of the crust in the section is 330—450 μ. The central cells of the coaxial hypothallium are 22—32 μ. long and 8—11, seldom up to 14 μ. broad, with rather thin walls. The cells of the perithallium are commonly squarish, 6—10 μ. in diameter, with the greater length partly in horizontal, partly in vertical direction. In the former case they may be only 5 μ. by 9 μ., in the latter case very seldom up to 14 μ. long. This form being compared with *L. fragilissimum*, the perithallic layers of both species will show almost complete conformity. The structure of the hypothallium is also much the same as in *L. fragilissimum*, but the cells are here mostly longer. I have previously pointed out that the hypothallium can be much varying with several calcareous algae and show a comparatively greater variety than the perithallium, a fact which is — partly at all events — owing to the shape and nature of the substratum. In the case in hand the variety is even less than in several recent species. The material, however, is scarce, and the fossil form is sterile. Therefore, I don't venture to identify it at present, but at any rate I must consider it as a

1) K. MARTIN. Lithothamnium in cretaceischen und jüngeren Ablagerungen tropischer Inseln. — Centralbl. für Mineralogie etc. 1901, p. 163.

species closely connected with *L fragilissimum*. In the sections "121. Soëk. v. Rosenberg (6)" a few small fragments occur, which seem to belong to the same species. It here appears together with numerous fragments of *Amphiroa* and other calcareous algae, among which *Mastophora melobesioides* classified below.

In the same section as fig. 6 *B* also the calcareous alga represented in fig. 6 *C* is to be found. It probably represents a species different from the above mentioned one. The cells are here usually 11—20 or sometimes up to 25 μ. long and mostly 7—10 μ. broad. It is, however, hardly to be ascertained what group it belongs to.

According to MARTIN l. c. the species, in the sense taken by him, also occurs at Timor, where the fossil sediments "sind stellenweise so vorherrschend aus Kalkalgen gebildet, dass man sie nur als fossile Lithothamnien-Bänke bezeichnen kann. Das gilt besonders für das Vorkommen von der kleinen Insel Samauw, gegenüber Kupang". — It is unknown to me which of the forms mentioned above is here represented.

4. *Lithothamnion simulans* Fosl. mscr.

Lithothamnion siamense f. simulans Fosl. Corall in SCHMIDT, Fl. Koh Chang II, p. 19.

f. *typica*. Fig. 7; Pl. I, fig. 24—25.

FOSLIE l. c.

f. *crispescens* Fosl. mscr. Pl. I, fig. 21—23.

Thallus more or less lamellate and crispate, or plicate-leaf-like.

Stat. 78. Lumu-Lumu-shoal, Borneo-bank. 34 m. Coral and Coralsand.
Stat. 81. Pulu Sebangkatan, Borneo-bank. 34 m. Coral bottom and Lithothamnion.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom. Sand and coral.
Stat. 125. Sawan, Siau Island. 27 m. Stone and some Lithothamnion.
Stat. 213. Saleyer and Surroundings. Reef.
Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m.
Stat. 258. Tual, Kei Islands. 5—12 m. Lithothamnion, sand and coral.
Stat. 261. Elat, West coast of Great-Kei Island. Reef.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.
Stat. 299. Buka or Cyrus Bay, South-coast of Rotti Island. 34 m. Mud, coral and Lithothamnion.
Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Coral and Lithothamnion.
Stat. 322. $1^1/_2$ mile south of Tandjong Lajar, South coast of Bawean Island. 32 m. Coral.

In Fl. Koh Chang l. c. I described the above plant as a form of *Lithothamnion siamense* and remarked: "I have been in doubt whether f. *simulans* ought not perhaps to be considered as a separate species, but as I have seen only a solitary well developed specimen of this form, I do not venture [1]) to keep it distinct, especially since the material also of f. *minuta* is scarce and some of the specimens no doubt are somewhat stunted". The material in hand from the

1) As it will appear from the connexion l. c. p. 30, l. 19 from below "venture" is to be read instead of the word "hesitate", owing to a slip of the pen.

Siboga expedition shows, however, that the two forms mentioned represent different species, and that the typical specimen from the Gulf of Siam has been young. The plant assumes thicker and more extensive crusts, which however are rather varying, and the conceptacles of sporangia generally prove to be larger than in the specimen mentioned. I therefore place it here as an independent species.

In a young stage the plant clings closely and rather firmly to the substratum. Even when advanced, it may be fairly closely adherent, though it is in part gradually detaching itself. On a large and even substratum the crust becomes rather smooth (Pl. I, fig. 24). If the substratum is small and branched, it certainly conforms fairly to it in shape, but is more loosely attached to it or partly growing quite freely. Pl. I, fig. 25 shows a form growing on corals, partly loosely encompassing the branches of the coral, partly even distended between the latter. This form comes also nearest to the typical one. If the plant is charged with extraneous objects, new crusts are formed above, which give rise to irregular or branchlike formations. Cp. Pl. I, fig. 21, representing a form intermediate between f. *typica* and f. *crispescens*, however most closely allied to the latter This form is distinguished by its thallus being more or less lamellate and crispate, or plicate-leaf-like (Pl. I, fig. 22—23). It corresponds partly to *Lithothamnion Philippii* f. *crispata*, partly to *L. Engelhartii* f. *imbricata* and f. *pseudocrispata*[1]), with which forms it has partially much in common, though distinctly separated particularly as to the conceptacles of sporangia. The form seems peculiarly to rise, when the substratum is irregular or of less firm consistency.

The species is attached to different objects, partly to shells of molluscs, partly and particularly to corals, calcareous sediment or other calcareous algae. Thus the specimen pictured in pl. I, fig. 24 has coalesced with *Archaeolithothamnion erythraeum*, which it partly covers. A small portion of the last mentioned alga is to be seen at the bottom of the picture. The same specimen is also quite covering a young *Goniolithon Reinboldi*. It sometimes anastomoses with *Lithothamnion fragilissimum*, and it even occurs on rather fine-branched species, as *Lithophyllum moluccense* and *L. Bamleri*, but is here less typical. So also when it sticks to *Archaeolithothamnion timorense*. The plant is thus less dependent on the substratum than several other species.

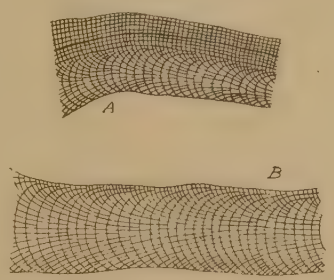

Fig. 7. *Lithothamnion simulans* Fosl. *A*. Vertical section of a crust rather adherent to the substratum; × 72. *B*. Radial section of a part of a crust growing freely; × 72.

Sections of the crust show that the hypothallium is frequently marked coaxial. The cells of this layer are 12—18 μ. or now and then up to 22 μ. long by a breadth of 6—12 μ. The perithallium is slightly developed, especially in such parts of the crust which are growing more or less freely. Sometimes it may, however, be rather vigorous and even stratified. The cells are square, often with rounded corners, 5—7 μ. in diameter, or slightly vertically elongated, in the latter case here and there up to 12 μ. long; fig. 7.

1) This form from Tasmania, referred by HEYDRICH to *Lithothamnion crispatum* Hauck, I have classified in Melob. Arb. Heydr. p. 27 as a denominated form of *L. Engelhartii*. It is, however, possible that it only represents a more irregular *L. Engelhartii* f. *imbricata*. I have only seen a sterile specimen.

The reproductive organs hitherto known are sporangia and cystocarps which occur on different specimens. The former are subhemispheric, however now and then at length somewhat flattened in the central parts, 500 (400)—700 μ. in diameter, when seen from above. They are sometimes to be found overgrown by a new-formed layer of tissue extending itself over the roof before the latter gets dissolved. The sporangia are four-parted, about 140—160 by 60—80 μ. The conceptacles of cystocarps are conical, frequently low, but rather acute, 600 (500)—800 μ. in diameter when seen from the surface. The species is furnished with the said organs, especially sporangia, in the months of January, February, June, November and December, mostly however rather scantily.

As to the relation to other species is to be observed that young specimens are rather approaching to *L. siamense*; but at an older stage the species is much differing from the latter. It approaches nearly to *L. fragilissimum*, from which it sometimes is hardly distinguishable in a sterile stage, whereas on the other hand fertile specimens are easily recognized. In habit it also comes near to certain forms of *L. Engelhartii*. On the other hand it is much like *L. funafutiense* f. *purpurascens*, particularly as regards the conceptacles of sporangia. Although the material of the latter form is very scanty, I now suppose it ought to be considered as a distinct species.

Occurrence: There are only a couple of specimens from each of the stations above quoted, from the station 125 even only a sterile and uncertain specimen. This fact seems to be indicative that the species occurs but sparingly over a great part of the East-Indian Archipelago.

Area: North Pacific: The Gulf of Siam.

5. *Lithothamnion prolifer* Fosl. mscr. Fig. 8; Pl. I, fig. 17—20.

Thallus crustlike, irregularly extended, 0,5—1 mm. thick, scantily prolificating, with irregular excrescences. Conceptacles of sporangia subprominent, at length rather flattened, 800—1100 μ. in diameter.

Stat. 78. Lumu-Lumu-shoal, Borneo-bank. 34 m. Coral and coralsand.
Stat. 81. Pulu Sebangkatan, Borneo-bank. 34 m. Coral bottom and Lithothamnion.

The plant forms irregular crusts on other calcareous algae, or different hard objects. The crust is 0,5—1 mm. thick and of a hard consistency. In a young stage the plant clings to the substratum and fairly conforms to it in shape, but afterwards it detaches itself little by little. In the downwards turned detached part of the crust it is distinctly concentric zonate, partly even forming rather deep striae, or furrowed. It is scantily prolificating, and besides it develops irregular or short branchlike excrescences. The specimens in hand show several such excrescences, which, however, are only owing to the form of the substratum or to foreign bodies having attached themselves to the plant or its substratum, and then having been overgrown with new-formed tissue. The excrescences seem to occur rather scarcely in typically developed specimens (Pl. I, fig. 19—20). The specimen pictured in pl. I, fig. 17 shows branchlike formations which are apparently large and vigorous, still mainly owing their rise to the form

of the substratum. This specimen, however, is on the whole somewhat differing, and only bears a solitary conceptacle of sporangia which is but slightly developed.

On a radial section of the crust the hypothallium appears vigorously developed, but the cells are smaller, than usual with species whose crusts develop themselves partially freely. The central cells are mostly but slightly elongated, 8—15 or up to 18 μ. long and 6—12 μ. broad and sends forth upwards rather long bent dichotomous rows of cells, but downwards short ones. It is, however, to be noticed that for the time I only possess somewhat oblique sections which are not properly representative of the structure of the hypothallium. The perithallium is also vigorously developed and either not stratified or indistinctly so to judge from the material examined. The cells of this layer are square, mostly with rounded corners, slightly elongated horizontally or vertically, 4—7 μ. in diameter, or more definitely vertically elongated, 7—10 or sometimes up to 12 μ. long. The walls of the cells are generally fairly thick (Fig. 8).

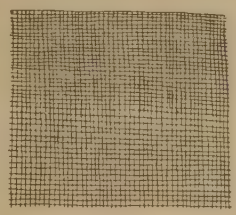

Fig. 8.
Lithothamnion prolifer Fosl.
Vertical section of the perithallic layer; × 72.

The reproductive organs known are sporangia. The conceptacles are subprominent or in part but very slightly raised above the surface of the plant, finally rather flattened, 800—1100 μ. in diameter, when seen from above. They are partly not sharply defined. The roof is intersected with about 100 muciferous canals. The sporangia are four-parted, 150—200 by 80—100 μ., with enduring partition walls. The plant is sparingly furnished with these organs in the month of June.

This species is found associated with *Lithothamnion fragilissimum* and *L. simulans*, and partly shares substratum with the former. Young specimens resemble *L. fragilissimum* a little in habit. As to reproductive organs hitherto known it comes very near to *L. Philippi*. On the other hand the plant is next akin to *L. funafutiense*, from which species, however, it is distinguished by mostly larger conceptacles and by detaching itself from the substratum. Besides there is some divergency as to structure.

Occurrence: The species seems to be of no frequent occurrence at the stations mentioned above. It was found best developed at the station 81.

c. Ramosa.

6. *Lithothamnion fruticulosum* (Kütz.) Fosl. Fig. 9, ex parte.

List of Lith. p. 6 (non Norw. Lith.); Spongites fruticulosa Kütz. Polyp. Calcif. p. 33 et Tab. Phyc. 19, t. 99. Syn. L. fasciculatum β fruticulosum Hauck, Meeresalg. p. 274.

f. *pteridoides* Fosl. mscr. Pl. II, fig. 1—4.

Resembling f. crassiuscula except that the conceptacles of cystocarps are less distinctly defined, lower and with a more distinct acute tip.

f. *clavulata* Fosl. Pl. II, fig. 5—9.

Corall. in SCHMIDT, Fl. Koh Chang, p. 17.

Stat. 64. Kambaragi Bay, Tanah Djampeah. Up to 32 m. Coral, coralsand.
Stat. 66. Bank between islands of Bahuluwang and Tambolungan, south of Saleyer. 8 to 10 m. Dead coral, Halimeda, Lithothamnion.
Stat. 78. Lumu-Lumu-shoal, Borneo bank. 34 m. Coral and coralsand.
Stat. 91. Muaras-reef, inner side: East coast of Borneo.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom. Sand and coral.
Stat. 106. Off Kapul Island, Sulu Archipelago. 13 m. Coral-bottom.
Stat. 109. Off Pulu Tongkil, Sulu Archipelago. 13 m. Lithothamnion-bottom.
Stat. 123. North Bay. Biaru Island. 36—27 m. Stone and Lithothamnion-bottom.
Stat. 125. Off Sawan, Siau Island. 27 m. Stone and some Lithothamnion.
Stat. 133. Lirung, Salibabu Island. Reef.
Stat. 136. Ternate-anchorage. 23 m. Mud and stone.
Stat. 155. Piapis Bay (Telok Sapira) Northwest coast of Waigeu Island. Reef.
Stat. 240. Banda-anchorage. From 9—45 m. Lithothamnion bank in 18—36 m.
Stat. 250. Kilsuin, West-coast of Kur Island. 20—45 m. Coral and Lithothamnion.
Stat. 258. Tual-anchorage, Kei Islands. 22 m. Lithothamnion, sand and coral.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island. Reef.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.
Stat. 299. Buka or Cyrus Bay, South-coast of Rotti Island. 34 m. Mud, coral and Lithothamnion.
Stat. 322. 1 1/2 mile south of Tandjong Lajar, South-coast of Bawean Island. 32 m. Coral.

In Fl. Koh Chang l. c. I referred some small and not well developed specimens from the Gulf of Siam to the above species, the only specimens of this species then known from the Pacific. They resemble delicate specimens of a form from the Mediterranean and the Adriatic which I proposed to name f. *clavulata*.

I have afterwards referred a few other and similar specimens from the Maldives to the same form of the species [1]). As I then remarked, the latter also agree in habit and structure with somewhat stunted growths from the Mediterranean and the Adriatic. The only difference appears to be that the conceptacles of cystocarps are more conical or more acute than generally seen in specimens from the last named regions. As remarked, there seems to be no reason to consider this alga as a form so differing from the Mediterranean and Adriatic f. *clavulata* as to be specially denominated. Besides, in delicate branching specimens from the said regions the cystocarpic conceptacles sometimes may be even as conical as in those from the Maldives, especially when they are developed in the tip of the branches, and then somewhat differing from those in a coarse f. *crassiuscula*.

The mentioned collection from the Maldives also contained some other and coarser specimens which partly coincide with *L. fruticulosum* f. *crassiuscula*. (l. c. pl. XXIV, fig. 2), partly appear to be somewhat differing (l. c. pl, XXIV, fig. 3). I have however been unable to distinguish even the latter specimen from the form *crassiuscula*, and therefore I consider it only to represent an extreme variation of the said form. Cp. l. c. p. 465.

1) M. Foslie. The Lithothamnia of the Maldives and Laccadives. — The Fauna and Geography of the Maldive and Laccadive Archipelagoes, Vol. I, Part. 4. Cambridge 1902, Pag. 464, Pl. XXIV—XXV.

In another paper [1]) I have pictured three specimens from the south coast of Australia together with specimens from the Mediterranean and the Adriatic. Also the Australian form seems to be identic with f. *crassiuscula*. Cp. l. c. pl. I, fig. 4—9. It appears to be abundant in certain localities in Port Philip Bay, Victoria. It is richly provided with conceptacles of sporangia. The other reproductive organs are however quite wanting in a rather large number of specimens examined, while in Adriatic specimens cystocarps are rather more common than sporangia, but on the other hand antheridia are very scarce.

I have shown in the paper mentioned that the Mediterranean as well as especially the Adriatic forms of the present species are much varying in habit and partly even in structure too. So also in regard to the forms from the Maldives. As remarked l. c., this appears partly to depend on local conditions, partly on the fact that *L. fruticulosum* is as a rule more burdened with extraneous objects than most other Lithothamnia, and therefore more irregularly developed.

In the collection in hand from the Siboga Expedition occur a number of specimens which, as far as ascertainable, are identic with or very nearly related to *L. fruticulosum*. However, many of them have been dead or water worn when collected, and germinating plants of one or other species have often attached themselves to such specimens and are gradually covering them more or less. But above all, the specimens are much burdened with extraneous objects, and, therefore, they are more or less stunted or irregularly developed. The nature of the bottom seems in many cases to have been unfit for the development of the species, i. e. it has been rather loose, and there has been too little of hard objects for fastening the plant, which is often burdened also with a mixture of clay and sand. It is frequently attached to fragments of corals or dead calcareous algae, anastomosed with or attached to other living species, but on the other hand also often serving as a substratum to other and especially crustlike Lithothamnia, as well as numerous Squamariaceae. I have met with up to seven or eight species anastomosed in one piece not more than 2—3 cm. in diameter, or one species fully or in part covering the other. Fig. 9 shows samples of such anastomosed species. In addition there are specimens which are partly covered with young crusts of other species, closely and firmly

Fig. 9. Anastomosed or partly overgrown specimens of:
A. (Stat. 282).
Lithothamnion fruticulosum (Kütz.) Fosl.
Lithothamnion australe Fosl. forma.
Lithophyllum Okamurai Fosl.?
Lithophyllum sp.
Squamariacea.
(Corals, bryozoa, worms).
B. (Stat. 109).
Lithothamnion fruticulosum (Kütz.) Fosl.
Lithothamnion australe Fosl. forma.
Lithothamnion sp.
Lithophyllum Okamurai Fosl.?
Lithophyllum sp.
Mastophora melobesioides Fosl.
Peyssonnelia sp.
Another Squamariacea.
(Corals, bryozoa, worms); nat. size.

1) M. Foslie. Die Lithothamnien des Adriatischen Meeres und Marokkos. — Wissensch. Meeresuntersuchungen, Abt. Helgoland. (In press.).

adhering and provided with reproductive organs, which on a cursory examination might be considered as a new thickening-layer of the thallus of the species in question. The specimens in this collection are even more burdened with lower animals than those from the other area mentioned, especially small corals, Bryozoa and numerous worms as well as boring algae, penetrating and disturbing the tissue. Thus, an intense struggle for existence is to be seen partly between the algae mutually, partly and especially between plant and animal. There is scarcely a single specimen not being burdened with such objects of one kind or other. Numerous new hypothallic layers are to be found in sections not only of the crustlike part of a specimen, but very often in branching forms too, and as a rule owing to extraneous objects. In other sections is often to be seen a conglomerate of divers calcareous algae (especially Lithothamnia as well as Squamariaceae) and animals, one more or less covering the other, sometimes even forming almost regularly alternating layers.

It is extremely difficult to define such stunted specimens with certainty, in several cases quite impossible. Besides, the very greatest number of specimens apparently belonging to the species in question are sterile, in some cases provided with sporangia, seldom are to be seen a few conceptacles of cystocarps, and not a single one with antheridia. Such specimens scantily fertile have been collected in the months of May, June, July and December. Therefore, it must be the subject of future investigations to show to what extent the forms here mentioned really belong to the species to which they are now referred. It may also be noticed that several specimens come near to the following species, *L. australe*, and a sure delimitation can not be founded on the materials present, although, on the other hand, there is no doubt that the said species in fact are specifically distinct.

The form named f. *pteridoides* is partly resembling f. *crassiuscula* in habit, partly a little differing from it (Pl. II, fig. 1—4). The specimens of this form are, however, mostly young and not well developed. The crust is sometimes thicker than in typical specimens of f. *crassiuscula*, and on the other hand the branches are shorter, but this is owing to extraneous objects being covered up or other species attaching themselves to the crust and being overgrown. The consequence of this is a later and less vigorous development of the branches, such as to be seen in numerous specimens of *L. fruticulosum* from the Adriatic. As to structure the form in the main agrees with the other forms of the species. So also as regards the conceptacles of sporangia, which, however, are sometimes more confluent than in the other forms. The chief difference which is now to be ascertained is in the conceptacles of cystocarps. I have certainly seen but a few ones in young specimens, and — as formerly remarked — even these organs are somewhat varying in this species. The said conceptacles in f. *pteridoides* are of about the same diameter as in f. *crassiuscula*. Seen from above they are, however, less distinctly defined, lower, with a more acute and distinct tip than in the latter form, the conceptacles of which are frequently low conical, though more arched, or approaching a subhemispheric-conical shape, and the tip indistinct and apparently sooner falling away. It may however be observed that, as mentioned in Lithoth. Adriat. Meer., the conceptacles of cystocarps in f. *crassiuscula* may sometimes be rather high and almost superficial, sometimes low, but little prominent, and that when emptied they often become overgrown by new-formed tissue.

The specimens which I have referred to f. *clavulata* partly resemble those from the Gulf of Siam and the Maldives mentioned above, e. g. the branches are more delicate and often less developed than in typical specimens of this form (Pl. II, fig. 9). Other specimens resemble typical f. *clavulata* in habit and structure, or they are in part somewhat coarser (Pl. II, fig. 5—8). As remarked in Lithoth. Adriat. Meer. this form runs into f. *crassiuscula* without any proper limit. Cp. l. c. pl. I, fig. 4—6 and 10—15. It apparently stands in almost the same relation to f. *pteridoides* in the present collection, but cannot be elucidated till better material is known. The conceptacles of sporangia resemble those in Adriatic specimens, and as to the conceptacles of cystocarps, which are very scarce, I refer to my remarks above under the Maldive form.

In Lithoth. Adriat. Meer. I classified a delicate and sparingly branching form under the name of f. *soluta*. Cp. l. c. pl. I, fig. 18—33. I have l. c. in detail compared it with stunted forms of other species arising from external causes or certain local conditions. As observed l. c., this form perhaps represents a species being in evolution, and as yet too little differentiated to be looked upon as independent. Judging from the material in hand, however, this doesn't seem to be the case; it seems to be a dwarf-form which has risen from local conditions. There is no certain limit to be drawn between it and f. *clavulata*. As also observed l. c., the form certainly diverges a great deal from the typical *L. fruticulosum*. Still the divergency is but little greater than, for instance, that of *L. calcareum* f. *subsimplex* from f. *valida* of the same species, viewed apart from quite monstrous forms.

In the collection in hand occur some specimens which stand in nearly the same relation to f. *clavulata* as the Adriatic f. *soluta* mentioned. They have probably risen in the same way as the latter, e. g. selfloosening or broken branches of delicate specimens continuing their growth lying loose on the bottom. In habit these specimens, however, are less diverging from a small or stunted f. *clavulata* than the majority of the Adriatic specimens of f. *soluta*. On the other hand they are sometimes so near approaching to *L. australe* f. *minutula* that the line can hardly be drawn with certainty, the less so, because these forms in the collection in hand are represented, without any exception, by sterile specimens.

Occurrence: In the sense taken above the species appears to be commonly distributed over a great part of the investigated area. However, from most of the stations occur only a few specimens, and from some stations only one has been brought home; the greatest number have been brought home from stat. 109 and 240. A considerable bank of Lithothamnia at stat. 66, between the islands of Bahuluwang and Tambolungan, south of Saleyer, is mentioned by M. Weber [1]) and Madame A. Weber [2]). This bank is not unlikely, at least in part, built up with the species in question. There occurs, however, but a solitary small specimen from this place. The specimen is in the lower part composed of a conglomerate of tubes of worms, Bryozoa and other animals together with dead and living calcareous algae. Among the latter is *Mastophora melobesioides*, covered partly with lower animals, partly *Peyssonnelia* sp. and the

1) Siboga-Expeditie I. Max Weber. Introduction et Description de L'Expédition. p. 38.

2) A. Weber-van Bosse. Études sur les Algues de L'Archipel Malaisien. — Annales du Jardin Botanique de Buitenzorg. Ser. 2, Vol. II, Leide 1901, p. 131.

species in question. The upper layers of this irregularly crustlike piece with wart-like or short branch-like excrescences are formed by a very small crust of *Lithothamnion* sp. as well as *Lithophyllum* sp., but in the main by a plant not well developed which seems to belong to f. *pteridoides* of the species in question.

Area: North Atlantic: The southern part of the Atlantic coast of Europa (f. *crassiuscula*, rare), Mediterranean (f. *ramulosa*, f. *crassiuscula*, f. *clavulata*), Adriatic (the same forms as well as f. *soluta*); Indic: The Red Sea (not quite certain), the Maldives (f. *crassiuscula*, f. *clavulata*), and the south coast of Australia (f. *crassiuscula*); North Pacific: The Gulf of Siam (f. *clavulata*).

7. *Lithothamnion australe* Fosl. Fig. 10.

L. coralloides f. australis Fosl. Norw. Lith. p. 62, ex parte; New or crit. Lith. p. 8, fig. 6—7; L. australe Fosl. Rev. Syst. Surv. Melob. p. 13.

f. *tualensis* Fosl. mscr. Fig. 11; Pl. II, fig. 10—17.

Thallus irregularly branching, shrub-like, 1—2 cm. in diameter; branches short and more or less spreading, often curved and knotty, about 1,5 mm. thick. Conceptacles of sporangia slightly prominent, 400—550 μ. in diameter.

f. *ubiana* Fosl. mscr. Pl. II, fig. 18—24.

Thallus forming roundish nodules about 2 cm. in diameter, with rather straight and subfastigiate branches 1—2 mm. thick, partly rather crowded, partly somewhat spreading.

f. *brachiata* Fosl. mscr. Pl. II, fig. 25—38.

Thallus irregularly, rather sparingly branched, frequently with spreading and diverging branches 1—2 mm. in diameter. Conceptacles of sporangia 400—600 μ. in diameter.

f. *minutula* Fosl. mscr. Pl. II, fig. 39—62.

Thallus more or less branching, roundish or irregular, frequently 0,5—1 cm. in diameter; branches partly rather crowded, partly more or less spreading, frequently about 1 mm. thick.

Stat. 79. Pulu Kabala-dua, Borneo-bank. 22 m. Coralsand.
Stat. 86. Dongala, Palos Bay, Celebes. Reef.
Stat. 91. Muaras-reef, inner side: East coast of Borneo.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom. Sand and coral.
Stat. 99. Off North Ubian. 16—23 m. Lithothamnion-bottom.
Stat. 106. Off Kapul Island, Sulu Archipelago. 13 m. Coral-bottom.
Stat. 109. Off Pulu Tongkil, Sulu Archipelago. 13 m. Lithothamnion-bottom.
Stat. 149. Fau-anchorage, West coast of Gebé Island. 31 m. Coral.
Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m.
Stat. 258. Tual-anchorage, Kei Island. 22 m. Lithothamnion, sand and coral.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.
Stat. 299. Buka- or Cyrus Bay, South coast of Rotti Island. 34 m. Mud, coral and Lithothamnion.
Stat. 303. Haingsisi, Samau Island. Reef.
Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Sand, coral and mud.

In Norw. Lithoth. [1]) I placed among *Lithothamnion coralloides* Crn., then taken in a rather wide sense, a form which I named f. *australis*, and which has afterwards been partly ranked with *Lithothamnion calcareum* (Pall.) Aresch. The knowledge of *L. coralloides*, as well as of *L. calcareum*, was then insufficient, and decided fertile specimens were not in hand. As to the mutual relation of the two species mentioned, I refer to Lithoth. Adriat. Meer, where I have presumed that *L. coralloides* includes partly *L. calcareum*, partly *L. fruticulosum*, in the sense taken by CROUAN [2]), however, in the main only *L. calcareum*. Simultaneously with Norw. Lithoth. I published a paper where I classified f. *australis* from the Gulf of California [3]). This form constitutes the basis of *Lithothamnion australe*, entered into Rev. Syst. Surv. Melob. [4]). The said form from the Gulf of California is here named f. *americana*.

The question whether the forms from the East-Indian Archipelago, named above, actually belong to the same species as the American form is not to be settled at present, the material partly in the main consisting of sterile specimens, partly being too small. There are several specimens in the collection in hand which are in almost full conformity with the said American form. It is, however, to be observed that specimens of rather widely different species may often resemble each other in habit as well as in structure, and accordingly cannot be defined with certainty, when sterile. Besides it cannot — as yet — be ascertained to what extent there is a connection — as to this group of the algal flora — between the East-Indian Archipelago and the Pacific coast of America. I have, below, in treating of *Lithothamnion erubesceus*, mentioned some instances that seem to be indicative that the distribution of some species has a very wide range. At any rate, however, I do not find reason for the present to classify the forms in question as independent species (one or more), but I provisionally place them with *L. australe*.

The form *tualensis* mostly forms small shrub-like masses which appear to have developed themselves freely at the bottom, and generally are 1—2 or up to 3 cm. in diameter. It is subdichotomously or — oftener — repeatedly irregularly branched. The branches are partly somewhat crowded, partly — and more commonly — rather spreading, more or less curved, with short axes, frequently about 1,5 mm. thick, either slightly tapering or now and then slightly enlarged towards the tip, with rounded ends (Pl. II, fig. 10—17). This form comes near to *L. fruticulosum*, and particularly old specimens approach to certain forms of this species. Future investigations will ascertain the relations between them. I here place the form under *L. australe*, to which it — judging from the material in hand — is most closely allied. Among the specimens brought home a comparatively great number prove to have been wholly or partially dead, when collected. On these were often developed crusts of other calcareous algae, or new crusts of the same form, together with animals and other extraneous objects, had caused a very irregular development. Such specimens frequently show an appearance rather

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1) M. FOSLIE. The Norwegian Forms of Lithothamnion. — Det Kgl. Norske Videnskabers Selskabs Skrifter 1894. Trondhjem 1895, p. 62.

2) P. L. et H. M. CROUAN. Florule de Finistère. Paris, 1867, p. 151.

3) M. FOSLIE. New or critical Lithothamnia. — Det Kgl. Norske Vidensk. Selsk. Skrifter 1895, Trondhjem 1895, p. 8.

4) M. FOSLIE. Revised Systematical Survey of the Melobesieae. — Det Kgl. Norske Vidensk. Selsk. Skrifter, 1900, N°. 5, Trondhjem 1900, p. 13.

differing from specimens typically developed. Selfloosening or — I presume — more usually broken branches often seem to continue growing.

The form *ubiana* constitutes roundish nodules which also seem to have been freely developed at the bottom. It is generally 2 cm. in diameter and is distinguished by rather erect, subfastigiate and straight branches, which, however, are partly rather crowded and knotty, partly — and more frequently — somewhat spreading. The branches are, as a rule, longer than in the form *tualensis* and 1—2 mm. thick, partly tapering, partly — but more rarely — with somewhat thickened ends (Pl. II, fig. 18—24). Otherwise this form runs into the following one, and there is no distinct line between them.

The form *brachiata* is distinguished by spreading branches, more or less curved, sometimes rather elongated, of about the same diameter as in the form *ubiana*. There are partly delicate and sparingly branched specimens of this form. At any rate some of these specimens no doubt have risen from broken branches, either of young specimens, or of the last order of older specimens, continuing their growth. Thus there are such delicate specimens where one or more surfaces of fracture are covered with new-formed tissue.

The form of the species apparently most divergent is f. *minutula*. It is 0,5—1 cm. in diameter, partly very sparingly branched with spreading and frequently short branches, partly and oftener the branches are rather crowded, and sometimes it assumes an almost subfastigiate shape. The branches are either terete and slightly attenuating, or cylindrical, or now and then slightly thickened towards the rounded ends, about 1 mm. thick. There is a rather great number of specimens of this form from two stations, and they are of obvious conformity. Cp. pl. II, fig. 39—50 from stat. 109, and fig. 51—62 from stat. 282. As I mentioned in treating of *L. fruticulosum*, the form was sparingly mixed with specimens which seem to belong to f. *clavulata* of the latter species or to be closely connected with f. *soluta*, and which are on the whole hardly distinguishable. The other specimens, however, come nearest to *L. australe* in the sense here taken, though they are also mixed up with fragments or small specimens which may belong to another form not to be distinguished with certainty. There are several specimens showing a surface of fracture more or less distinct and covered with new-formed tissue. I take, however, f. *minutula* in the sense indicated by the specimens pictured. The form approaches partly to *L. australe* f. *tualensis*, partly to f. *brachiata*, and it might be supposed to have risen from both these forms and be considered as stunted specimens now of one, now of the other. But this is not probable. It is perhaps more likely representing an independent species, though all the specimens being sterile, it cannot for the time be settled. A sure definition of this form (as well as of the others) will only be realised by a number of fertile specimens or by investigations on the spot whether, for instance, the form constitutes small and in the main independent banks, as the northern species *Lithothamnion norvegicum* almost always sterile, which it somehow recalls, or if it only occurs together with other forms of the species.

What I remarked in treating of *L. fruticulosum* as to foreign bodies causing an irregular development, also refers to the forms ranked with the species in question, though certainly to a less extent. There are numerous specimens, particularly of the three forms first mentioned,

in which small corals are found having attached themselves and then having been overgrown, as a series of Bryozoa, attaching themselves to the plant and often overgrown by new layers of accretions, bring about an abnormal thickening of the branches of the plant. If the plant comes into contact with a foreign body, there may even be developed a rather extensive crust, as in several other species in which such a development is not normal. As is the case with *L. fruticulosum*, *L. calcareum* and others, it will equally be found with *L. australe* that germinating plants attach themselves partly to living specimens, partly to dead ones of the same species. If simultaneously or later on Bryozoa or other organisms attach themselves to such specimens, a more irregular development will be the result. In cases of recurrence, coarse forms will come into existence, greatly differing from typical specimens in appearance. Such a peculiar monstrous form of *L. calcareum* I have described and pictured in Lithoth. Adriat. Meer. Cp. l. c. pl. 3, fig. 1—7. In the collection in question there are some specimens which are most closely allied to f. *ubiana*, but coarser than typical specimens of the form, and approaching very nearly to certain forms of *L. fruticulosum*. These specimens at all events seem to have partly risen in the said way. Others in which two or more specimens seem to have been melted together, finally assume a shape little typical. If several species are growing gregarious in the same locality, and germs of such ones attach themselves to a different species or to a common substratum, complexes of species will rise like those under *L. fruticulosum* mentioned; fig. 9.

As to the structure of this species, it is to be observed that also in this respect the line distinguishing it from other species near of kin is hardly to be drawn with certainty. Indeed it is in part impossible. This is the case in the first place with branched forms of *L. fruticulosum*. On the other hand it is all but impossible to draw the line in the said respect between *L. australe* and *L. pulchrum*. Besides the forms of *L. australe* show mutually some variety, as specimens which are quite like each other in habit, are sometimes rather divergent in structure, and even in one and the same specimen the size of the cells is often rather varying. This variation in structure often also corresponds with a varying consistency, which in some specimens is looser than in other ones. A section of *L. australe* f. *americana*, parallel with the longitudinal axis of a branch, exhibits distinct cup-shaped layers of tissue. The cells of the medullary hypothallium are 14—22 μ. long and 7—14 μ. broad, with somewhat rounded corners. The perithallic cells are 8—18 μ. long and 7—12 μ. broad, or here and there roundish and only 6—8 μ. in diameter; fig. 10. A similar section of f. *tualensis* shows a structure in the main coinciding with that in the latter form. The medullary hypothallic cells are 12—22 μ., frequently 14—18, seldom up to 25 μ. long by a breadth of 7—12 μ., often with rather rounded corners. The perithallic cells are rectangular, 9—18 μ. long by 8—10 μ., now and then however roundish; fig. 11. The cells are in general a little shorter, proportionately to the breadth, in this form than in other forms, and the walls of the cells are often thicker. The structure of f. *ubiana* is rather varying.

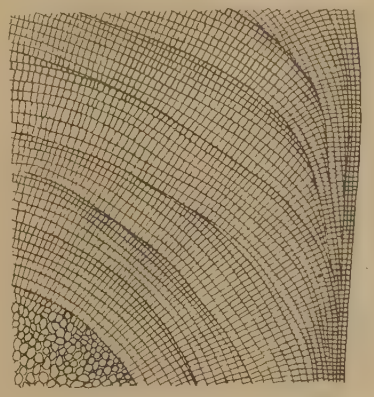

Fig. 10.
Lithothamnion australe Fosl. f. *americana*.
Part of a median section of a branch; × 72.

The cells are partly of the same size as those of the last mentioned form, partly throughout a little smaller, partly — and as a general thing — longer, the hypothallic ones sometimes being up to .30 μ. long. Such is also the case with f. *brachiata*, the cells of which are also partly a little longer throughout than those of f. *tualensis*, partly, however, quite like the latter in structure. On the other hand the structure of f. *brachiata* is even approaching to that of *Lithothamnion erubescens* with more regular cells and thinner walls, than usual in any form of *L. australe*. Also the structure of f. *minutula* is rather varying and shows conformity partly with that of f. *tualensis*, partly with that of f. *brachiata*.

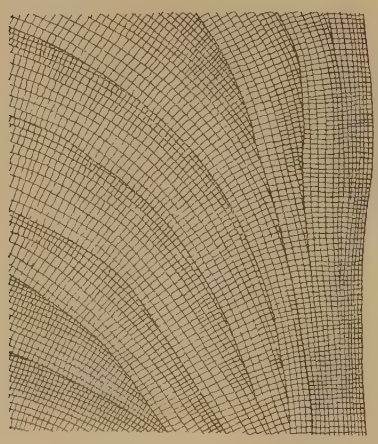

Fig. 11.
Lithothamnion australe Fosl. f. *tualensis*.
Part of a median section of a branch; × 72.

As to structure, *L. australe* thus presents about the same variety as *L. fruticulosum*, though perhaps in a less degree, as in the latter a considerable difference is prevailing between specimens crustily spread with short branches and branched specimens which have lain free on the bottom. The cells of the latter are always longer than those of the former, and in the Adriatic f. *ramulosa* always lying free on the bottom the hypothallic cells are generally even longer than in a much branching f. *crassiuscula*, and can attain a length of up to about 30 μ. *L. australe* is, therefore, most closely connected with branched forms of the said species.

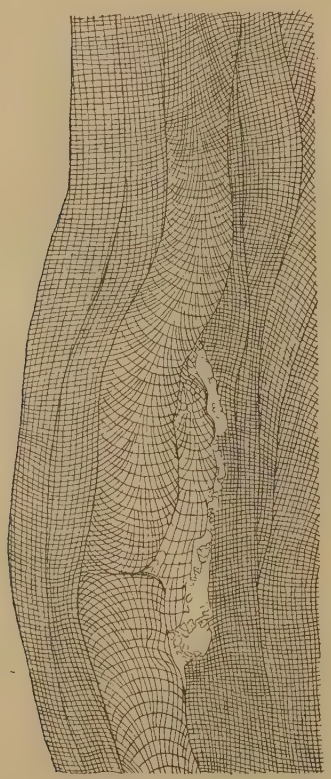

Fig. 12.
Lithothamnion australe Fosl. f. *ubiana*.
Part of a median section of a branch of a coarse specimen, with a new-formed coaxial hypothallium covering a damaged part of the branch; × 72.

The varying habit and irregular development above mentioned due to extraneous objects, of course appear also in sections of the plant. But, on the other hand, irregular developments in the structure are often to be seen without any apparent external alteration, being however also in such cases caused by damage in some way or other, or by delicate extraneous objects attached to the plant (Fig. 12). The latter represents a small part of a median section of a branch of a rather coarse specimen which comes nearest to f. *ubiana*. Here a part of the branch has been damaged or burdened with delicate foreign bodies. A new and even marked coaxial hypothallium is then formed, resembling the said layer of tissue in several crustlike species. This hypothallium issues from the surrounding undamaged parts of the perithallic layer towards the centre of the damaged part. When this part has been covered with the new hypothallium, the latter sends forth perithallic rows in connection with new thickening layers in the parts of the branch which have remained unhurt.

As mentioned above, I have met with very few reproductive organs in *L. australe*. Thus only a couple of specimens of f. *tualensis* are furnished with a few conceptacles of sporangia. These specimens were taken in the month

of December. The conceptacles are but little prominent and not sharply defined, when seen from above, 400—550 μ. in diameter. They appear, however, not to be fully developed. The sporangia are unknown. I have seen a specimen of f. *brachiata* from stat. 303 (pl. II, fig. 25) furnished with a couple of conceptacles, these too not sharply defined and about 600—700 μ. in diameter. Another specimen from stat. 99 (pl. II, fig. 31) collected in June, is the only one of this species that shows a fairly rich development of the said organs. Here too most of them are not fully developed and partly quite young. The conceptacles are a little more prominent than those of f. *tualensis* and very like those of the specimen last mentioned, partly however not sharply defined. They are partly circular in circumference, partly approaching an oblong shape, when seen from above, rather scattered here and there in the branches, although two or three sometimes may be almost confluent, 400—600 μ. in diameter. I have not seen the sporangia. In f. *ubiana* and f. *minutula* I have found no conceptacles of sporangia. And cystocarps and antheridia are wanting in all the four forms.

I have also seen specimens from Samoa (Bot. Mus. Hamburg), which are partly connected with *L. australe* in the sense here taken, partly approaching to certain forms of *L. fruticulosum*. But also these specimens were sterile.

It seems unquestionable to me that f. *ubiana* and f. *brachiata* belong to one and the same species, even though there are specimens which apparently belong to the former, but — as stated above — on the other hand are nearly approaching to certain forms of *L. fruticulosum*. There are also some specimens, particularly from stat. 282, which are partly closely allied to *L. australe* f. *ubiana* or f. *brachiata*, partly approaching to *L. fruticulosum* f. *ramulosa* occurring in the Mediterranean and the Adriatic, or to forms of *L. calcareum* occurring in the said area as well as in the Atlantic Ocean. Among these is found a flabellate and sterile specimen, about 3 cm. in diameter, which in habit bears a striking resemblance to *L. calcareum* f. *palmatifida*. On the other hand it is closely approaching to some of the doubtful, likewise sterile, specimens above mentioned which are perhaps representative of a species or form as yet undescribed. It cannot, however, be elucidated till fertile specimens are known. In treating of f. *tualensis* and f. *minutula* I have already suggested that these forms are possibly representing independent species.

In addition to the relations stated to the species already mentioned it is to be observed that *L. australe* sometimes obviously approaches to young specimens of *L. pulchrum*, in habit even in a higher degree to young *Archaeolithothamnion timorense*. Sometimes it may also be hardly distinguishable with certainty from young and sterile specimens of *L. erubescens* f. *haingsisiana*.

Occurrence: Forma *tualensis* is known from stat. 79[b], from which, however, only a single specimen is in hand, which presumably belongs to this form, and from stat. 258, where the plant seems to form a rather large bank; (cp. the introduction). The form *minutula* too is only known from two stations, viz. stat. 109 and 258. The two other forms are taken at almost all the stations quoted, partly alone, partly and mostly associated with each other and with other species.

Area: South Pacific: Samoa (not certain); North Pacific: The Gulf of California (f. *americana*).

8. *Lithothamnion Dickiei* Fosl. Fig. 13—14.

New or crit. calc. Alg. p. 7.
Lithothamnion polymorphum Dickie, Linn. Soc. Journ. Bot. Vol. XV, Pag. 452.
Lithothamnion imbricatum Dickie, herb.; nec Zan.

Stat. 61. Lamakera, Solor Island. 20 m. Coral and sand.
Stat. 81. Pulu Sebangkatan, Borneo-bank. 34 m. Coral bottom and Lithothamnion.

With some doubt I ascribe a couple of specimens to this species. The plant is up to the present unsufficiently known, and its delimitation is yet hardly to be ascertained. Fig. 13 exhibits a fairly entire specimen and three fragments which are the types of the species kept in the British Museum. The former is about 7,5 by 5,5 cm. in diameter and about 2 cm. thick. It has perhaps been at first attached to some hard object, but has afterwards detached itself and continued its growth freely at the bottom. There are also a few fragments kept in Kew Gardens herbarium. In Suppl. Alg. Tahiti [1]) the plant is mentioned as follows: "A calcareous alga in rounded masses forming the bottom in 10 fathoms off Great Island (Santa Cruz Major), Zambonga. The dredge came up filled with these masses". The thallus has a short mainstem which is either flattened and upwards broadening, or very short and almost terete, and from which issue branch-systems repeatedly subflabellate or irregular, spreading almost in one plane, one above the other. The branches, more or less compressed, are about 1,5 or up to 2 mm. thick, and frequently much confluent with each other. The tip of the branches are partly rounded, partly almost truncate. The specimens or fragments examined are very scantily furnished with conceptacles of sporangia. The latter are subprominent, flattened in the central parts, or occasionally almost disc-shaped, though sometimes not sharply defined, 350—400 μ. in diameter when seen from above. The roof is intersected with about 30 coarse muciferous canals. Sporangia are not known.

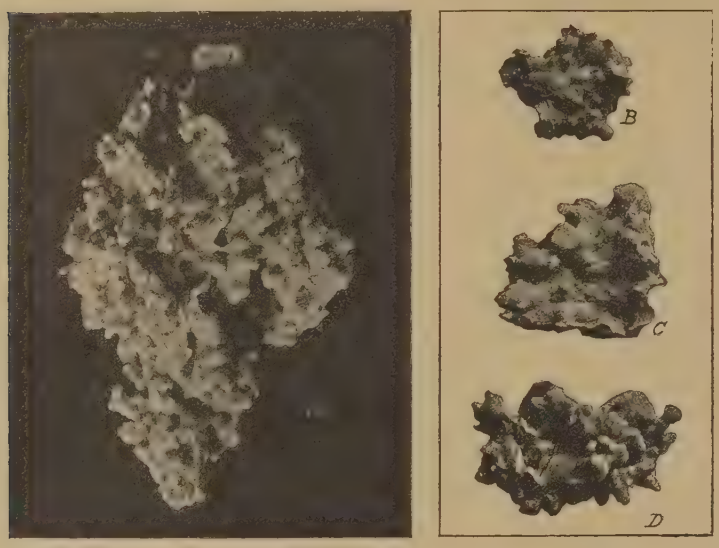

Fig. 13. *Lithothamnion Dickiei* Fosl.
The type specimens from Tahiti; *A*, seen a little from the side; nat. size.

From the scanty material hitherto known it is impossible to settle the directions of variation within the species. It seems, however, to come nearest to *Lithothamnion erubescens*, the species next described, though less in habit than in structure. When I first described the plant, I had reason to suppose that it was distinct from any other species then known. Nor did

1) Dickie. Notes on Algae collected by H. N. Moseley of H. M. S. "Challenger", chiefly obtained in Torres Straits, Coasts of Japan, and Juan Fernandez. Linn. Soc. Journ. Bot. Vol. XV, p. 452: 8. Algae collected on the Reefs of Tahiti. 9. Supplement to preceding collection.

its relationship now presumed to the said species suggest itself, the type specimens being very different Cp. fig. 13 and 15. However, in *L. Dickiei* the more or less plane branch-systems one above the other differ from those in any form of *L. erubescens*. Besides, in the type specimen the cells are more irregular than in the latter, partly smaller, partly however of about the same size, although as a rule a little broader proportionally to the length.

The specimen in the collection in hand from stat. 61 is attached to a piece of a coral. In habit it agrees rather well with *L. Dickiei*, though it is younger and the branch-systems are less plane and the branches in part a little thinner than in the type specimen above mentioned (Fig. 14 *A*). It is unfortunately sterile, and in regard to structure it almost coincides with *L. erubescens*, but, on the other hand, it is not likely to be ascribed to the latter. I must at any rate at present consider it to be a form of the species in question. The other specimen, which was brought home from stat. 81, is very stunted and burdened with several extraneous objects (Fig. 14 *B*). As to structure, it coincides even more with *L. erubescens* than the specimen from stat. 61, but on account of other characters it seems also to have to be referred to the species in question. It bears a few conceptacles of sporangia not well developed.

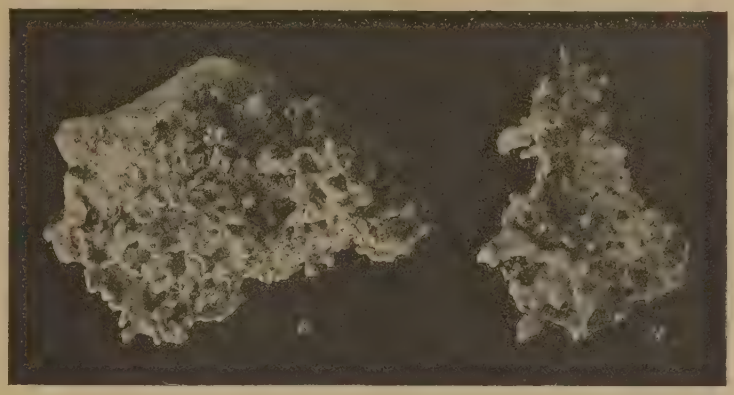

Fig. 14 *Lithothamnion Dickiei* Fosl.
A, stat. 61; *B*, stat. 81; nat. size.

Occurrence: Only one specimen known from each of the stations above quoted.
Area: South Pacific: Tahiti.

9. *Lithothamnion erubescens* Fosl. Fig. 15—16; Pl. III, fig. 20.

New or crit. calc. Alg. p. 9.
Syn. Lithothamnion mamillare Dickie, ex parte; nec Harv.

f. *haingsisiana* A. Web. et Fosl. Fig. 17; Pl. III, fig. 1—19, 21—22.

Three new Lithoth. p. 4.

f. *subflabellata* Fosl. mscr. Pl. III, fig. 23—25.
The branch-systems more or less flabellate, and the branches compressed or subcompressed.

Stat. 60 and 303. Haingsisi, Samau Island, Timor. Lithothamnion in 3 m. and less. Reef.
Stat. 91. Muaras-reef, inner side: East coast of Borneo. Karang Lintang and Pulu Palabangan Island. Lithothamnion near the islands.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom. Sand and coral.
Stat. 149. Fau-anchorage. West coast of Gebé Island. 31 m. Coral.

Stat. 193. Sanana Bay, East coast of Sula Besi. Reef.
Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.

As before mentioned (l. c.), I have not been able to draw any definite line between the type of this species from the coast of Brazil and the nearly allied forms occurring in the Indic and Pacific Oceans. The former I have named f. *americana*. Cp. fig. 15, representing the three specimens of this form hitherto known, on which was based the original description of the species. Fig. 15 *B* shows one of the specimens seen from the side. A reproduction of the same specimen is to be found on pl. III, fig. 20, here seen from above. Also from Bermuda a couple of specimens are known, which seem to have to be ascribed to the same form of the species, though the cells are here partly a little smaller than in the type specimens. From the same spot I have classified a form which I have named f. *prostrata* [1]).

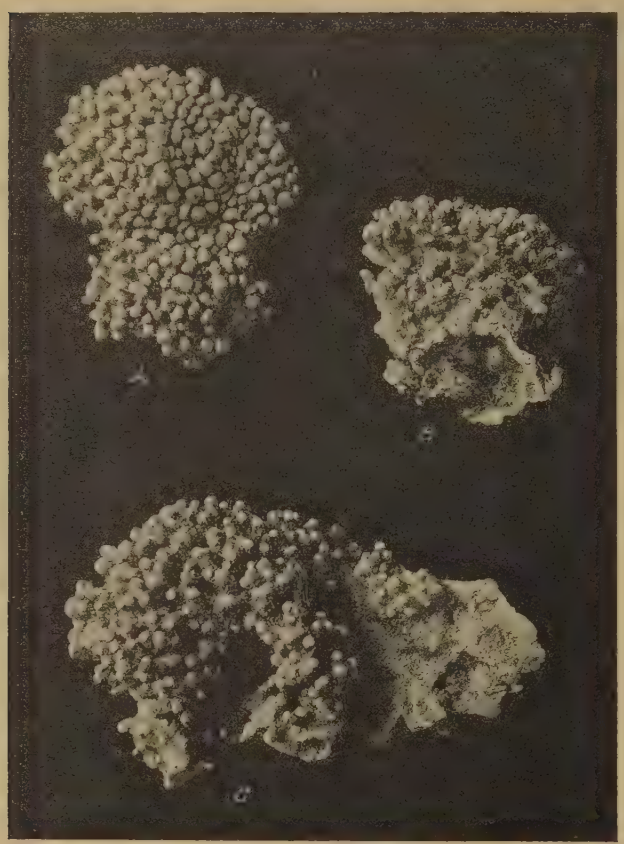

Fig. 15. *Lithothamnion erubescens* f. *americana* Fosl.
The type specimens from Fernando do Noronha; *B* also represented pl. III, fig. 20, seen from above; nat. size.

Before entering upon the forms occurring in the East-Indian Archipelago which seem to have to be ascribed to the same species, I want to make some remarks as to the geographical distribution of this group of algae.

Viewed apart from some few species of the genus *Melobesia*, which are forming thin crusts on other algae and are widely distributed in the Atlantic as well as the Indian Ocean and parts of the Pacific, the geographical distribution of the other unarticulated calcareous algae of this tribe is still rather uncertain and unsufficiently explained. I have earlier pointed out the fact that they are often very local. As efficients of essential importance are also to be considered the facts that they partly, or rather usually, lay other claims to the physical quality of the bottom than the majority of other algae, and that their occurrence is very dependent on sets of currents and tide. Owing to these circumstances the species are often much varying, and occur here and there in forms more stunted than perhaps any group of other Florideae, and in forms which may be almost unrecognizable and generally only occur as sterile or sparingly fertile. This is, however, also to a great extent due to the

1) M. Foslie. New Melobesieae. — Det Kgl. Norske Vidensk. Selsk. Skrifter. 1900. n⁰ 6. Trondhjem 1901, p. 3.

fact that these algae are much harassed by lower animals or on the whole much encumbered with different extraneous objects, and, therefore, have to carry on a hard struggle for existence. Consequently these algae must be supposed — at any rate to some degree — to be more checked than others in their distribution over larger areas. It is possible that also other efficients make their play contributing to impede the distribution of some species.

However, it must be considered as proved that some of the forms in question are distributed over great parts of the Pacific and the Indic Oceans, probably also of the Atlantic. But the limits of this distribution are rather uncertain, and above all it is as yet difficult to realize, whether any species occurring in the Malay or Pacific Archipelagoes concerns the Pacific or Atlantic coasts of America. This seems, however, to be the case with e. g. *Lithophyllum oncodes*, which probably also occurs both on the southern coast of California and in the West Indies. On the other hand, *Goniolithon Reinboldi*, apparently widely distributed in the Indian Ocean and common in the Malay Archipelago, has up to the present not been met with farther to the east, than at the Sandwich Islands in the North Pacific. In addition, a great deal may be said in favour of the notion that among the species of calcareous algae hitherto described from different areas, there are some identical ones, or one is likely to be considered only as a somewhat varying form of the other. Thus *Lithophyllum pallescens* Fosl. [1]) (including *L. californiense* Heydr.) from the Gulf of California is so closely allied to *Lithophyllum Okamurai*, classified in this paper, from the Pacific coast of Japan and several places in the Malay Archipelago, that the limit is hardly to be drawn. This is also the case with *Lithophyllum decipiens*, from the coast of South America [2]) and apparently also of the West Indies, in relation to *Lithophyllum Yendoi*, mentioned below, from Japan and some other places in the Pacific.

For the present, I therefore, find no reason to classify the forms of *Lithothamnion erubescens* from the East-Indian Archipelago as an independent species, the less so, as it has been impossible to me to draw any certain line. On the other hand it is certainly to be observed that the direction of variation within a species is hardly to be stated only from some few specimens, as is the case with f. *americana* of the said species. In fact there are independent species both of the genus *Lithothamnion* and *Lithophyllum* which are so closely allied to each other that their mutual relations only can be fully characterized on the ground of a fairly considerable material from several places. On the other hand there are instances where, judging from a scanty material, plants were considered as fairly well defined species which afterwards a larger collection have shown to be but varying forms, parly even but local forms of one and the same species. It is further to be observed that the only reproductive organs hitherto known of *L. erubescens* are sporangia. The other reproductions organs are unknown, and it will probably be the discovery of these organs that will decide the delimitation of the species.

By comparing the specimens of *L. erubescens* f. *haingsisiana* pictured in pl. III, fig. 1—19 and 21—22, with the specimens of f. *americana* reproduced in fig. 15 and pl. III, fig. 20, no difference in habit worth mentioning will urge itself between older and well developed

1) M. Foslie. New or critical Lithothamnia. — Det Kgl. Norske Vidensk. Selsk. Skrifter 1895. Trondhjem 1895, p. 4.

2) M. Foslie. Calcareous Algae from Fuegia. — Wissensch. Ergebnisse der Schwedischen Expedition nach den Magellansländern 1895—97. Stockholm 1900, p. 71.

specimens of both forms. The form *haingsisiana* is partly attached to other hard objects, as the specimens of f. *americana* hitherto known, and then gradually forms a thin crust over the substratum, partly it develops itself freely, or detached parts of the plant continue their growth freely, on the bottom. In the latter cases it may — in a young stage — show an appearance somewhat diverging from older and densely branched specimens (Pl. III, fig. 1—11). This form is — for the rest — somewhat varying both in habit and in structure. Among the rather great number of specimens from stat. 303 there are some less typical ones, showing a more irregular branching, and less fastigiate (Pl. III, fig. 12 and 15). Others are a little coarser and show transition to f. *subflabellata*. As stated l. c., the branches of f. *americana* are mostly 1,25—1,75 mm. thick. The branches of f. *haingsisiana* are generally of the same thickness. But particularly in specimens that are more or less approaching to f. *subflabellata*, the branches may be about 2 mm. thick. The majority of specimens from stat. 240 are also less typical, partly in habit, partly also in structure, particulars of which are found below. They are also somewhat stunted and much burdened with extraneous objects. (Pl. III, fig. 21—22). The specimens in hand from stat. 193 partly resemble typical f. *haingsisiana*, partly they are a little coarser. A single specimen from each of the stations 93 and 149 is in habit most closely allied to the same from stat. 240. In f. *americana* as well as in f. *haingsisiana* the upper part of the plant may be somewhat worn by the action of a very strong current. In such specimens the branches are more or less truncate. Live specimens of f. *haingsisiana* are pink-coloured, judging from a coloured specimen in the collection. In dried state it is mostly whitish or slightly purplish, frequently, however, with a greenish shade. It attains a diameter of about 9 cm.

The form *subflabellata* is distinguished by its compressed and less crowded branches or more or less flabellate branch-systems. It is a little coarser than f. *haingsisiana*, the branches usually being 2—2,25 mm. thick (Pl. III, fig. 23—25). Of the specimens here pictured fig. 23 represents an intermediate form between the forms mentioned. Both seem to have occurred associated with each other. The form *subflabellata* is coarser and also in other respects somewhat diverging from the form *prostrata* known from Bermuda.

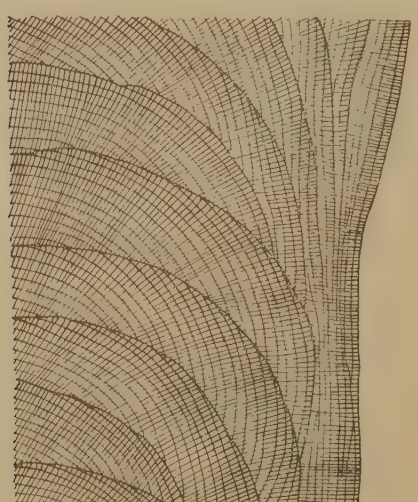

Fig. 16.
Lithothamnion erubescens Fosl. f. *americana*.
Part of a median section of a branch; × 72.

As regards structure, I have mentioned before (l. c.) that the cells of f. *haingsisiana* are often slightly broader, with slightly thicker walls, than those of the type of the species. From an examination of a number of specimens of f. *haingsisiana*, the structure proves to be so far varying that in this respect too no line is to be drawn. In f. *americana* the cells of the medullary hypothallium are in general about twice as long as broad, partly however longer, partly and often shorter, or 12—22, here and there but 10, frequently 14—18 μ. long and 7—10, seldom up to 12 μ. broad, with rather thin walls. The perithallic cells are partly square, 4—6 μ. in diameter, partly and most frequently vertically elongated and 7—12 or seldom up to 15 μ. long (Fig. 16). In f. *haingsisiana* the medullary hypothallic cells resemble those

of f. *americana*, but they are on the whole less regular. There is similarity also as regards the perithallic cells, though those of f. *haingsisiana* sometimes show a little thicker walls than those of f. *americana*, of which on the other hand only a single specimen has been examined (Fig. 17). In the above mentioned specimens from stat. 240 the structure partly fully resembles typical f. *haingsisiana*, partly the medullary hypothallium shows mostly a little shorter cells with corners partially rounded and thicker walls. Besides the perithallic layer is more vigorously developed, frequently with a little smaller and more thick-walled cells than in typical specimens. In these specimens a new hypothallium often stretches itself partially over the branches and covers roughnesses or extraneous objects. Such is also the case with the above mentioned specimens from stat. 93 and 149. These specimens of the plant somewhat differing and more or less stunted come very near to f. *madagascarensis* [1]), especially in structure. I have however seen but a single specimen of the latter from Madagascar, and besides a few quite young ones from the Pacific coast of Japan, which seem to belong to the same form. It may be that f. *madagascarensis* represents an independent species, but this cannot at present be decided.

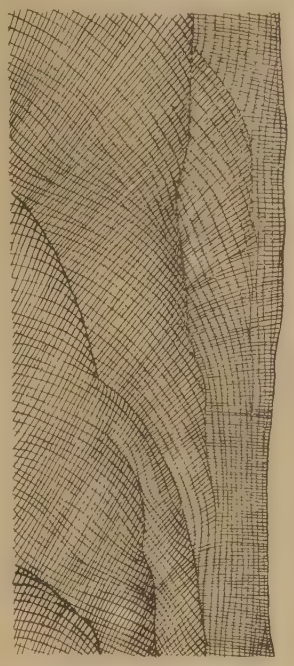

Fig. 17.
Lithothamnion erubescens Fosl. f. *haingsisiana* A. Web. et Fosl. Part of a median section of a branch; × 72.

The conceptacles of sporangia in f. *americana* are somewhat prominent and rather crowded in the upper part of the branches, 300—400 μ. in diameter, when seen from above. The roof is often rather flattened in the central parts and here traversed by about 20 muciferous canals. In f. *haingsisiana* they are of about the same size and more or less prominent, exceptionally however up to 450 μ. in diameter. The conceptacles at length become overgrown by new-formed tissue, but such ones are not commonly seen in the specimens examined, and they are in most cases peripherical. The sporangia are four-parted, about 90 μ. long and 50 μ. broad.

The very greatest number of the specimens collected are sterile. It seems to be the same case with this species as with several northern or arctic ones that reproductive organs are as a rule no more developed in old specimens, but mostly to be found only in somewhat younger specimens. — On the other hand, the said organs are to be found even in quite young specimens of certain species, especially crustlike ones. The form *haingsisiana* is scantily furnished with sporangia in the months of February, June, August and November, and f. *subflabellata* in the month of November.

The species in question seems to be most closely allied to *Lithothamnion Dickiei*, the species last mentioned. It resembles a little certain forms of *Lithothamnion falsellum* in habit, but is quite different in structure. It also recalls the northern species *Lithothamnion dimorphum*. On the other hand it comes very near to *Goniolithon frutescens* f. *congesta* in habit. Cp. pl. III,

1) M. Foslie. New Forms of Lithothamnia. — Det Kgl. Norske Vidensk. Selsk. Skrifter, 1901, N°. 3. Trondhjem 1901, p. 3.

pl. X, fig. 10—11, and Lithoth. Mald. and Laccad., fig. 5—6. Even in structure it somewhat approaches the latter species especially as regards the shape and size of the cells of the medullary hypothallium, but the perithallic layer is differing. Thus heterocysts are missing which are characteristic of *Goniolithon*. Besides in *G. frutescens* there is but indistinct, if any, stratification in the medullary hypothallium, whereas *L. erubescens* exhibits distinct but often rather irregular cup-shaped layers of tissue, and the consistency is looser in the former than in the latter. Therefore, even sterile specimens of both species are easily separated when closely examined. Young specimens of *L. erubescens* may be confounded with young ones of other species, for inst. *Archaeolithothamnion timorense*, especially however *Lithothamnion australe*.

Occurrence: At stat. 303 the plant forms a large and extended bank in the lowest part of the litoral and upper part of the sublitoral region, sparingly mingled with specimens of *Lithothamnion australe* f. *brachiata*, *Goniolithon Reinboldi* and *Lithophyllum Okamurai*, perhaps also other species (Fig. 1—2). Its occurrence here is recorded by Madame A. Weber-van Bosse [1]). At stat. 240 it seems also to have occurred in some number. On the other hand there are but a few specimens from stat. 193, and a solitary and not well developed specimen from each of the stations 93 and 149.

Area: North Pacific: Japan (Hinga), not certain; Indic: Madagascar (f. *madagascarensis*); South Atlantic: Chaloup Bay, Fernando do Noronha, Brazil (f. *americana*); North Atlantic: Bermuda (f. *americana*, f. *prostrata*).

10. *Lithothamnion pulchrum* A. Web. et Fosl. Fig. 18; Pl. IV.

Three new Lithoth. p. 3.

Stat. 96. South-east side of Pearl-bank, Sulu Archipelago. 15 m. Lithothamnion bottom.
Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Coral and Lithothamnion.

The plant forms roundish shrub-like masses up to about 10 cm. in diameter. The branches, issuing from a slightly thickened centre, are subdichotomously or irregularly divided, partly rather spreading and somewhat curved, partly more crowded, often with rather long axes and side-branches issuing at an almost right angle, terete or subcompressed, either cylindrical, or slightly tapering, or now and then slightly thickening towards the tip, with the ends rounded, 2—3, frequently about 2,5 mm. in diameter.

As remarked l. c., the species seems mostly to develop itself freely at the bottom. Among the gathered specimens I have found none that had developed itself attached to any hard object. But when extraneous objects attach themselves to the plant, it develops a thin crust and tends to cover the object (Pl. IV, fig. 6). In the specimen here pictured a shell of a mollusc is enclosed between the outermost branches. The shell is in part covered with a thin crust issuing from the branches that have been in contact with it. So also in the specimen represented pl. IV, fig. 9. Here several branches have been covered with some lower animals,

1) A. Weber-van Bosse. Études sur les Algues de L'Archipel Malaisien. — Annales du Jardin Botanique de Buitenzorg. Ser. 2, Vol. II, Leide 1901, p. 132. — Cp. also the introduction of the present paper.

apparently Bryozoa, even filling the intervals between some crowded and in part dead branches. These Bryozoa are again for a great part covered with a crust of the plant. The incrustment rises from the nearest branches alive, and by and by it develops new branches too. Still in other specimens new crust-like formations are developed over dead branches or extraneous objects, sometimes issuing from branches being alive, sometimes, as it seems, formed from germinating plants which have attached themselves to the said branches. In this case too new branches are developed in a rather early stage of the said formation (Pl. IV, fig. 5 and 10—11). In the specimen last quoted a small and young specimen of the same species has been brought into contact with two of the outermost branches. Then a crustlike formation some mm. broad has been developed, issuing from both the said branches in a semicircle around one of the branches of the said young specimen, thus fastening the latter, although but partially anastomosed with it. These cases seem to indicate that the species perhaps sometimes attaches itself to small objects, at first forming a crust over the latter, and afterwards loosening itself. In addition broken or loosened branches probably continue their growth freely at the bottom.

A section parallel to the longitudinal axis of a branch exhibits superposed, generally distinctly separate and rather regular cup-shaped layers of tissue, the cells of which are arranged in rows radiating in the shape of a fan, such as in most of the branching species of this genus. The cells of the medullary hypothallium are rectangular, often however with somewhat rounded corners, the length being frequently twice the breadth or larger by a half. The length varies between 12 μ. (occasionally less) and 30 μ., frequently 16—22, the breadth between 7 and 14 μ. The lower cells of each of the said cup-shaped layers appear longer, rectangular, the uppermost ones shorter or often almost square, as in most of the Lithothamnia forming similar layers. The cells of the perithallium are squarish or rectangular, frequently with thicker walls than the former, 6—14 μ. long and 6—9 μ. broad; fig. 18.

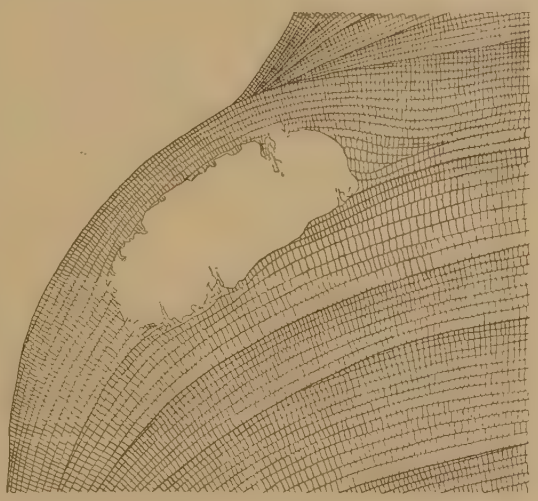

Fig. 18. *Lithothamnion pulchrum* A. Web. et Fosl. Part of a median section of a branch, with a supposed conceptacle of sporangia overgrown; × 72.

The organs of reproduction are unknown in the species in question. However, as remarked l. c. the plant must be considered to be a true *Lithothamnion*, judging from a solitary cavity resembling an emptied conceptacle of sporangia, which appears just below the surface in a section of a branch. This supposed conceptacle is about 550 μ. in diameter by a height of about 220 μ., and is overgrown with a few layers of cells. It is however to be observed that the walls of the conceptacle have partly been torn away during the grinding of the section; fig. 18. Therefore, it cannot be realized whether it actually represents the said organ, although there is every probability it does. In another, but fragmentary, section of a rather young specimen, in habit and structure fully resembling the species in question, are to be found a few other overgrown conceptacles, which also seem to

indicate that the plant is a *Lithothamnion*. They are only 200—300 by 75—110 μ. in diameter, but the sections are apparently not median ones.

The species on one hand resembles certain forms of the arctic *Lithothamnion tophiforme* in habit, and on the other hand it may sometimes be difficult to distinguish it from *Archaeolithothamnion timorense*. Especially young specimens are sometimes almost quite like certain forms of this species in habit and are in this respect hardly distinguishable. Cp. pl. IV and pl. VIII, fig. 1—14. The surface is however a little shining and smoother than in the said species. Even in structure they often much approach one another. Thus the cells of the medullary hypothallium are of about the same size in both, in *L. pulchrum* however less regular and frequently a little broader, and the corners are more rounded. Besides, the cup-shaped layers of tissue are more distinct in the species in question, whereas on the other hand in *A. timorense* they partly appear indistinct, partly and most frequently are not to be seen in a section. The perithallic layer is more distinctly marked towards the hypothallic one, and the cells of the former are generally smaller than in *A. timorense*. The most certain distinguishing feature is, however, the presence of small oblique intermediate cells in *A. timorense*, which are quite wanting in *L. pulchrum*. This character allows of the distinction even of sterile specimens. But the said cells are often not easily descried when the section is not quite thin. In addition, young specimens are hardly distinguishable from certain forms of *Lithothamnion australe*.

Occurrence: There are several specimens from stat. 315, where the species has probably been rather abundant, but from stat. 96 there is only a solitary, though well developed one. A few and likewise sterile specimens from stat. 282 belong perhaps to this species. They have been brought home together with some specimens which partly belong to *Archaeolithothamnion timorense*, partly are somewhat differing and uncertain.

Archaeolithothamnion (Rothpl.) Fosl.

1. *Archaeolithothamnion erythraeum* (Rothpl.) Fosl.

Rev. Syst. Surv. Melob. p. 8.
A. Rothpletz. Über eine neue Pflanze (Lithothamnium erythraeum n. sp.) des Rothen Meeres. Bot. Centralbl. 1893, N° 14.

f. *dura* (Heydr.) Fosl. Pl. V.

L. c. p. 8. Sporolithon ptychoides f. dura Heydr. in Ber. der Deutsch. Bot. Gesellsch. 1897, p. 67.

f. *mollis* (Heydr.) Fosl. Pl. VI.

L. c. p. 8. Sporolithon ptychoides f. mollis Heydr. l. c. p. 67.
Syn. Sporolithon ptychoides Heydr. l. c. p. 415.
Syn. Sp. molle Heydr. l. c. p. 416.
Syn. Sp. crassum Heydr. l. c. p. 417.

Stat. 47. Bima. Reef.
Stat. 71. Makassar and surroundings. (Pulu Barang, Samolana, Ley-Ley). Up to 32 m.
Stat. 81. Pulu Sebangkatan, Borneo-bank. 34 m. Coral bottom and Lithothamnion.
Stat. 86. Dongala, Palos Bay, Celebes. Reef.

Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom.
Stat. 96. South-East side of Pearl-bank, Sulu Archipelago. 15 m. Lithothamnion bottom.
Stat. 99. Off North-Ubian. 16—23 m. Lithothamnion bottom.
Stat. 109. Off Pulu Tongkil, Sulu Archipelago. 13 m. Lithothamnion bottom.
Stat. 123. North Bay, Biaru Island. 36—27 m. Stone and Lithothamnion bottom.
Stat. 125. Off Sawan, Siau Island. 27 m. Stone and some Lithothamnion.
Stat. 133. Lirung, Salibabu Island. Up to 36 m. Mud and hard sand.
Stat. 169. Atjatuning, West coast of New-Guinea. Reef.
Stat. 172. Gisser, anchorage between this island and Ceram-Laut. 18 m. Coral- and Lithothamnion bottom and Reef.
Stat. 193. Sanana Bay, East coast of Sula Besi. Reef.
Stat. 213. Saleyer and surroundings. Reef.
Stat. 220. Pasir Pandjang, West coast of Binongka. Reef.
Stat. 234. Nalahia Bay, Nusa-Laut Island. Reef.
Stat. 240. Banda-anchorage. Lithothamnion-bank in 18—36 m.
Stat. 250. Kilsuin, West-coast van Kur Island. 20—45 m. Coral and Lithothamnion.
Stat. 261. Elat, West-coast of Great-Kei Island. Reef.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island. Reef.
Stat. 296. Noimini, South coast of Timor. Reef.
Stat. 299. Buka- or Cyrus Bay, South coast of Rotti Island. 34 m. Mud, coral and Lithothamnion.
Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Coral and Lithothamnion.

A part of the type specimen of this species, from El Tor in the Red Sea, is represented pl. V, fig. 1, and two other fragments from Obock in the Gulf of Aden pl. V, fig. 3 and 4.

As formerly stated by myself, *Sporolithon ptychoides* Heydr. is identic with the above species. *Sp. ptychoides* was at first divided by HEYDRICH l. c. into two forms, f. *dura* and f. *mollis*. Afterwards he considered f. *dura* as an independent species, the type of *Sp. ptychoides* in a more restricted sense than formerly. At the same time he divided f. *mollis* into two separate species, which he named *Sp. molle* and *Sp. crassum*, and the latter in its turn was divided into two forms, f. *typica* and f. *variabilis*. From a comparison of the descriptions l. c. as well as the illustrations l. c. pl. III, fig. 15—23, it will be realized that there is no real distinction between the three species last named and *A. erythraeum*, neither as regards habit nor as to structure. The latter is a rather varying species, the habit of which often depends on local conditions and the shape of the substratum to which the plant is attached. Therefore, I have classified only two forms, mainly in the same sense as they were first described by HEYDRICH l. c., viz. f. *dura* and f. *mollis* of which fragmentary but authentic specimens from El Tor, distributed by HEYDRICH himself, are represented pl. V, fig. 2 and pl. VI, fig. 1.

The form *dura* is generally distinguished by thick and densely crowded branches (pl. V). In f. *mollis* the branches frequently are thinner and less crowded than in the former (pl. VI). Numerous transitions are, however, to be found, so that a certain limit can not be drawn. Both forms partly grow gregariously, partly in different localities.

As far as hitherto known, the species in question always attaches itself to some hard object, corals, stones or other calcareous algae. Detached parts of the plant, however, seem to continue their growth freely on the bottom, although apparently seldom. The plant sometimes fully surrounds the object, especially when the latter is a small one. It partly develops excrescences or branches in a rather early stage, partly in a later stage and particularly when the

substratum is large. In the latter case the crust frequently grows thicker than in the former. In this respect it resembles several other species, for inst. *Lithothamnion fruticulosum*. It is as a rule much burdened with extraneous objects of one kind or other. Thus the inner or lower parts of a specimen may sometimes be almost fully destroyed by boring-muscles, or other specimens are traversed with numerous, wider or finer, passages made by worms. In addition, different animals attach themselves to the surface of the plant and become more or less overgrown by new formed tissue. This contributes to an irregular development of the plant. New crusts are often developed over the primary one, sometimes even more crusts, one above the other, and such new formations often expand over the primary excrescences or short branches. In such cases the branches not seldom become coarser than otherwise (Pl. V, fig. 8—10). So also when germinating plants attach themselves to more or less knotty corals, dead specimens of the same species, or to other calcareous algae with wart-like excrescences or short branches. On pl. V, fig. 11 is represented a specimen with a coral nucleus. The latter has been covered with *Goniolithon Reinboldi*, and this species has in its turn been almost fully covered with the species in question. Here and there in the said specimen appear two crusts of *A. erythraeum*, one above the other, the first crust covered with a thin layer of other organisms, apparently lower animals, and then the other one developed over the said layer, both, however, covering *G. Reinboldi*. Besides wart-like excrescences or short branches are also in this specimen developed apart from those which have risen from covering up the densely crowded branches of *G. Reinboldi*. Some uncovered branches of the latter species provided with conceptacles are to be seen in the uppermost part as well as to the right on the quoted picture. The branches of the species in question are on the whole much varying, and in one and the same specimen are often to be found some ones several times thicker than others (Pl. V, fig. 2, 4, 5, 10, 12). Sometimes the plant becomes worn and rubbed in the upwards turning part by the action of a strong current, in the same way as often to be seen in *Lithothamnion dimorphum* and other species. The edges of such worn branches now and then get covered by new formations of tissue issuing from the next undamaged parts of the plant (Pl. V, fig. 7).

In regard to the structure of the forms above mentioned I refer to my former remarks on this species [1]). I have there shown that the measures given by HEYDRICH l. c. are not correct. The hypothallic layer of the crust is composed of more or less bent rows, the cells of which are up to about 40 μ. long, frequently however shorter. The cells of the medullary hypothallium are 10—22, frequently 12—18 μ. long and about 9—10 μ. broad. The perithallic cells are partly about 8 μ. square, partly of nearly the same length as those of the medullary hypothallium. However, now and then appear rather irregularly alternating long and short cells. In addition, the minute square and oblique intermediate cells sometimes appear almost everywhere in a section, sometimes apparently but here and there.

The reproductive organs known are cystocarps and sporangia. The former seem, however,

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1) M. FOSLIE. Bieten die HEYDRICH'schen Melobesien-Arbeiten eine sichere Grundlage? — Det. Kgl. Norske Vidensk. Selsk. Skrifter. Trondhjem 1901, N⁰. 2, p. 16.

rather seldom to occur. There are a rather great number of specimens in the Siboga collection, but only a couple are provided with the said organs. The conceptacles are convex or subhemispheric-conical, about 300—600 μ. in diameter, when seen from the surface, but not sharply defined. Externally they are rather like the corresponding organs in certain forms of *Lithophyllum*, but otherwise they come near to those in *Goniolithon*, as the carpospores arise from any part of the conjugation cell. Sporangia are on the other hand common, and the sori are partly to be found overgrown in great numbers by new formed tissue, partly, however, they are not to be seen in a section. The sporangia are frequently 75—90 μ. long by a breadth of 35—55 μ.[1]). Fertile specimens have been collected nearly all the year.

Occurrence: Only one specimen has been brought home from each of the stations 47, 109, 125, 133, 240, 296 and 311, a fact which seems to indicate that the species has been scarce in these places. From the other stations are 2—8 specimens. It is uncertain whether the plant forms banks at any of the quoted stations, alone or in company with other species, but most probably it does not, as it is nearly always attached to other hard objects, but apparently occurring both in the litoral and sublitoral regions. The species has also been met with at the following places on the north coast of New-Guinea, here collected by Prof. A. WICHMANN: Pulu Adi; Pulu Kelamala, east of Pulu Adi; Anggar-Mios Island, Geelvink Bay; and Sari (Sjari), west coast of Geelvink Bay[2]).

Area: Indic: The Red Sea; the Gulf of Aden; the Maldives.

2. *Archaeolithothamnion Sibogae* A. Web. et Fosl. Pl. VII.

Three new Lithoth. p. 3.

Stat. 86. Dongala, Palos Bay, Celebes.		Reef.
Stat. 96. South-east side of Pearl-bank, Sulu Archipelago.	15 m.	Lithothamnion bottom.
Stat. 99. Off North-Ubian.	16—23 m.	Lithothamnion bottom.

This species is shrub-like or roundish, up to about 7 cm. in diameter. The thallus is subdichotomously or irregularly branched, with axes of up to three orders. In typically developed specimens the branch-systems issue in all directions from the centre of the thallus. The branches are more or less spreading and curved, partly short, partly elongated and up to about 2 cm. long, terete or slightly compressed, frequently knotty, with the ends rounded, 3—6, generally 4—5 mm. in diameter. I have not seen any attached specimens, but the plant is perhaps attached at first to some hard object, although afterwards it detaches itself and lies free on the bottom. However, a partly dead specimen in the collection is anastomosed with a roundish extraneous object and apparently also fragments of another species, and besides it is burdened with extraneous objects. New layers of tissue are here and there developed over the dead parts of the plant, or partly stretched over the said objects as crustlike formations, from which short branches are developed, such as in *Lithothamnion pulchrum* and other species generally lying

1) The measures of the sporangia in the species of this genus refer to the size of overgrown cavities due to the said organs. The sporangia themselves are therefore in fact a little smaller.

2) The Dutch New Guinea Expedition 1902—1903.

free on the bottom (Pl. VII, fig. 16). Another and stunted specimen is anastomosed with two others, sterile and undeterminable calcareous algae, corals, sponges and Bryozoa, which seem to enclose a common nucleus of some hard object. The species in question has also in this case developed crustlike formations, from which issue short branches. The plant is in general rather burdened with extraneous objects, especially Bryozoa. Detached branches often appear to continue their growth, and the surface of fractures is soon effaced by new-formed tissue.

In a section parallel to the longitudinal axis of a branch the medullary hypothallium is composed of cells which are frequently rectangular, and the length of which is $1^1/_2$—2 times the breadth. The size varies between 10 and 22, seldom up to 28 μ. in length, generally 15—20 μ. by 8—11 μ. in breadth. They gradually decrease towards the perithallium, the cells of which are usually smaller than those of the hypothallium, varying from 5—8 μ. squarish and up to about 12 μ. in length. The limit between the said layers is however very indistinct. Here and there in the hypothallium as well as the perithallium are to be seen alternating short and longer cells, rather more commonly in this species than in the other ones of this genus. Minute square and oblique intermediate cells are numerous; they are 2—4 μ. in diameter.

In the specimens examined only a small number of sporangia occur. They are frequently 65—85 μ. long and 30—45 μ. broad. The other reproductive organs are unknown.

The species in question on one side approaches to coarse forms of *A. timorense*. Young as well as stunted specimens of both species are sometimes not easily distinguished. However, the plant is frequently much coarser than the said species, and the cells are as a rule a little smaller. On the other hand it occasionally recalls *A. erythraeum*.

Occurrence: The plant seems to have been fairly common at the stations 96 and 99, while only two rather young specimens have been brought home from stat. 86.

3. *Archaeolithothamnion timorense* Fosl. Pl. VIII, fig. 1—14.

Thallus freely developed at the bottom, shrub-like, 3—5 cm. in diameter, subdichotomously or irregularly branched; branches more or less spreading and curved, frequently knotty, terete or subcompressed, most often tapering, 1,5—2,5 mm. thick. Sporangia 70—90 μ. long by 35—50 μ. broad.

Stat. 99. Off North-Ubian. 16—23 m. Lithothamnion bottom.
Stat. 144. North of Salomakië (Damar) Island. 45 m. Coral bottom and Lithothamnion.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island. Reef.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.
Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Coral and Lithothamnion.

The plant is shrub-like or roundish, up to about 5 cm. in diameter. Judging from the gathered specimens, it develops itself freely at the bottom. Nor have I seen any specimen of this species attached to other objects, but sometimes anastomosed with small ones. In that case the plant little by little develops a thin crust over the object, such as in some of the species mentioned, for inst. *L. tenue*, *L. pulchrum*, *A. Sibogae*. So also it tends to cover Bryozoa or other animals which fasten themselves on or between the branches, or new formations

are developed over old and dead parts of the plant. This contributes to a more irregular development, with branches more crowded, now and then anastomosing and thicker than otherwise. The thallus is subdichotomously or irregularly branched, with axes of up to about three orders. In specimens typically developed the branches issue in all directions from the centre of the thallus. The branches are frequently rather spreading, partly fairly straight, partly and more generally curved, with side-branches which often issue at a right or almost right angle, and rather knotty especially in old specimens. They are terete or a little compressed, either cylindrical or more frequently tapering, seldom slightly enlarged towards the tip, with rounded ends, 1,5—2,5 mm. in diameter.

A median section of a branch shows partly rather regular cup-shaped layers of tissue, such as in most branching species of the genus *Lithothamnion*, partly the said layers are not to be seen, or very indistinct, such as in the other species of *Archaeolithothamnion*. The length of the cells of the medullary hypothallium is frequently $1^1/_2$—$2^1/_2$ times the breadth. They are 14—30 μ. long by a breadth of 7—14 μ., most commonly however 16—22 μ. long. The perithallic cells are partly 7—12 μ. square, partly elongated and then as a rule somewhat shorter than the hypothallic ones. Here and there appear irregularly alternating long and short cells. Intermediate oblique cells 2—4 μ. in diameter, also in this species are present in a rather large number particularly in the perithallic layer.

Some of the specimens collected are provided with sporangia, mostly, however, in small number. The said organs are 70—90 μ. long and 35—50 μ. broad. Cystocarps and antheridia are unknown.

Among the species of this genus hitherto known, *A. timorense* is intermediate between *A. Sibogae* and *A. Schmidtii*. On the other hand it is suggestive of certain forms of the northern *Lithothamnion tophiforme*. Besides, sterile specimens are sometimes almost undistinguishable from *Lithothamnion pulchrum*. Thus there are some from stat. 282, which partly appear to belong to *A. timorense* (pl. VIII, fig. 2), partly come very near to *L. pulchrum*, and are probably referable to the latter, although they are more densely branched, with shorter axes than usually to be seen in this species. A few of them, on the other hand, partly approach to *A. Schmidtii*, partly to delicate forms of *A. Sibogae* in habit. They cannot at present be fixed with certainty. The most typically developed specimens of the species are from stat. 315, but they are here in part rather burdened with extraneous objects (Pl. VIII, fig. 1, 3, 4—6, 9—12, 14). Some of those from stat. 277 are a little coarser, and the branches are less curved and less knotty (Pl. VIII, fig. 7—8, 13).

Occurrence: The plant seems to have been rather abundant at stat. 315, but apparently scarce at stat. 277 as well as at stat. 282. From stat. 99 have been brought home only a couple of specimens not quite typical, and from stat. 144 a single one.

4. *Archaeolithothamnion Schmidtii* Fosl. Pl. VIII, fig. 15—17.

Corall. in SCHMIDT, Fl. Koh. Chang, p. 16.

Stat. 96. South-east side of Pearl-bank, Sulu Archipelago. 15 m. Lithothamnion bottom.
Stat. 169. Off Adjatuning, West-coast of New-Guinea. Reef.

The species attaches itsef to corals or other hard objects, developing a feeble crust which attains a thickness of up to about 2 mm., frequently however less. From this crust more or less crowded branches are developed. The latter are either simple or subdichotomously divided, with short axes, partly increasing in thickness upwards, partly and rather seldom not, or with somewhat spherically thickened ends. The branches are 1,5—2 or occasionally up to 3 mm. thick, and they are often knotty.

A vertical section of the crustlike part of the plant exhibits a rather slightly developed hypothallic layer, composed of elongated cells which are up to about 20 μ. long, frequently however shorter. In a longitudinal section of a branch the medullary hypothallium is formed of cells most commonly $1^1/_2$—2 times longer than broad, or 10—18 μ., occasionally up to 22, generally however 12—16 μ. long and 7—11 μ. broad. The perithallic cells are 6—10 μ. square or up to about 14 μ. long. Irregularly alternating, long and very short, cells are seldom seen in the medullary hypothallium, as well as in the perithallic layer. Besides appear in both the said layers, particularly however in the perithallic one, square and oblique intermediate cells 2—4 μ. in diameter.

The only reproductive organs known are sporangia. They are 50—65, now and then up to 80 μ. long by a breadth of 30—40 or up to about 45 μ.

I considered l. c. the species in question to be a well marked one. It has, however, been stated that the species of this genus at present known are much varying and often not easily recognizable in their most extreme forms. Pl. VIII, fig. 15 represents a part of the type specimen of this species. It is burdened with several extraneous objects, which are partly covered with crustlike formations of tissue. The plant is as yet but little known, as till now only a few specimens have been collected. These are even from rather widely distant areas. However, it is most probably to be maintained as an independent species. It partly approaches to *A. erythraeum*, partly it is not easily distinguished from *A. timorense*, the species last described. It is separated from the former in the main by its thinner branches and frequently shorter cells as well es smaller sporangia. On the other hand it seems to be more closely allied to certain forms of *A. timorense*, particularly somewhat densely branched ones, but the latter species apparently always develops itself freely at the bottom and generally exhibits larger cells and sporangia.

Of the two specimens in the Siboga collection, especially that from New Guinea agrees well with *A. Schmidtii* (Pl. VIII, fig. 17). This is also the case with the other specimen but for its exhibiting cells which are often a little larger than in the former one (Pl. VIII, fig. 16).

Occurrence: Only one specimen brought home from each of the stations above quoted.

Area: North Pacific: The Gulf of Siam; Indic: The Maldives.

II. Melobesieae Aresch. (Fosl. emend.).

Goniolithon Fosl.

a. Crustacea (*Herpolithon* Fosl.).

1. *Goniolithon myriocarpon* Fosl. Pl. IX, fig. 6—7.

Lithoth. Adriat. Meer.
Lithothamnion myriocarpon Fosl. On some Lithoth. p. 19.

Stat. 86. Dongala, Palos Bay, Celebes. Reef.
Stat. 169. Atjatuning, West-coast of New-Guinea. Reef.
Stat. 225. South of Lucipara-group. Reef.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island. Reef.

In 1897 I described the above species represented by a solitary specimen, picked up at Massauah in the Red Sea. I have not afterwards met with it until last year, when I got a specimen for determination, collected at El Tor in the Red Sea by Dr. Plate, which proved to belong to the same species [1]). In Lithoth. Adriat. Meer. I have shown that the plant is a *Goniolithon*; but I am still uncertain whether this species and *G. Fosliei*, recorded below, really are specifically distinct. At any rate, they are closely allied to one another. There is no limit to be drawn in regard to habit, except that the crust as a rule will be thinner in *G. myriocarpon* than in *G. Fosliei*; and the surface is frequently rather smooth, now and then even a little shining in the latter, whereas it is rather dull in the former. The plant attaches itself to similar hard objects as *G. Fosliei*, viz. corals, shells or other calcareous algae. Sometimes it even forms very thin crusts on *Archaeolithothamnion erythraeum*, in a sterile stage scarcely distinguishable from the host plant except in a section, as it in habit gives the impression of a new thickening layer of the latter. Pl. IX, fig. 6, represents a part of the type specimen attached to a bucky, forming incrustations 100—200 μ. in thickness, closely and firmly adherent to the substratum. But it also becomes thicker, and it seems at length to attain nearly the same thickness as *G. Fosliei* (Pl. IX, fig. 7).

As to structure the cells of the perithallic layer are frequently smaller than in *G. Fosliei*, and often those of the hypothallium too are smaller. The latter layer of tissue sometimes is not marked coaxial, which, as far as hitherto seen, always is the case in the said species. Besides, the heterocysts appear in much smaller number than in *G. Fosliei*, often not even to be seen in a section.

There is certainly, however, no distinct limit to be drawn in the mentioned respects, the structure being rather varying in these species as in several others. The distinguishing feature apparently most significant is due to the reproductive organs. In the species in question only sporangia [2]) are known. The conceptacles are subprominent or often almost superficial, 450—650 μ. in diameter, when seen from the surface. Thus they show only about half the size of

1) Th. Reinbold. Meeresalgen von Tor (Sinai-Halbinsel, Rotes Meer). — Hedwigia. Bd. LXII, 1903, p. 232.
2) In the description of the species they are recorded as cystocarps, which is, however, wrong (antheridia uncertain).

the cystocarpic conceptacles of *G. Fosliei*, which are 800—1100 μ. in diameter, when seen from above, or sometimes even more. In typical specimens of the latter species sporangia have not yet been found. However, in Lithoth. Mald. and Laccad. I mentioned a specimen of *G. Fosliei* furnished with the said organs, which are of about the same size as in *G. myriocarpon*. But the specimen is not quite typical, as also here the cells are a little smaller than in a typical one from the same place bearing cystocarps, and the heterocysts scantily appearing. I should be most inclined to consider *G. myriocarpon* only to be the sporangia-bearing form of a common species including *G. Fosliei* as the cystocarpic form, the former developing a very small number of heterocysts. I have not yet had the opportunity of comparing more particularly other species of the genus *Goniolithon*, so as to be able to ascertain a similar state of things. However, in *G. Notarisii* sporangia-specimens partly exhibit a rather large number of heterocysts, partly they are scarce. In *G. elatocarpon*, a species closely allied, I have not seen heterocysts. Of this species, however, only a single specimen is known. The latter species stands in almost the same relation to *G. Notarisii* as *G. myriocarpon* to *G. Fosliei*, e. g. the cells frequently being smaller. It would be of considerable interest to realize the said relations particularly in regard to sexual and asexual forms of one and the same species within the genus *Goniolithon*, as well as the nearly allied genus *Melobesia*. Thus in the latter genus too the mutual relation between e. g. *M. farinosa* and *M. Lejolisii* is not yet fully elucidated. These species are in fact hardly distinguishable except for the heterocysts appearing in the former, and perhaps a small difference in the size of the cells.

I do not venture, however, at present to unite *G. myriocarpon* and *G. Fosliei*, partly owing to the mentioned differences in structure, partly and especially because the supposed relations in regard to the reproductive organs and the different appearance of the heterocysts are not yet settled.

Occurence: The plant seems to be rather widely dispersed, but apparently not occurring in great number at any of the quoted stations.

Area: Indic: The Red Sea.

2. *Goniolithon Fosliei* (Heydr.) Fosl. Fig. 19; Pl. IX, fig. 1—5.

Lithoth. Adriat. Meer.
Lithothamnion Fosliei Heydr. Corall. in Ber. der Deutsch. Bot. Gesellsch. 1897, p. 58; ex parte sec. spec.
Lithophyllum Fosliei Heydr. l. c. p. 410.

Stat. 71. Pulu Barang, near Makassar. Reef.
Stat. 78. Lumu-Lumu-shoal, Borneo-bank. Reef.
Stat. 91. Muaras-reef, inner side: East coast of Borneo.
Stat. 303. Haingsisi, Samau Island. Reef.

As for the apprehension of this species I refer to my remarks in Melob. Arb. Heydr. p. 8 and Lithoth. Mald. and Laccad. p. 470. An authentic specimen, distributed by Heydrich himself, is represented pl. IV, fig. 1, and a vertical section of the same specimen fig. 19 *A*.

In specimens typically developed the plant forms a rather even crust on divers hard objects, sometimes one crust formed above the other (Pl. IX, fig. 2, 3, 5). The crust attains a thickness of up to about 1 cm., frequently however less. It seldom develops excrescences, as far as I have seen. Such ones apparently often occur, but they are, in the specimens examined by me, at any rate as a rule, caused partly by the shape of the substratum, partly by covering up extraneous objects. Besides, they are often due to numerous, finer or wider, passages made by worms, around the orifices of which new formations of tissue are by and by heaped up, or the destruction of the inner layers, especially those just below the surface of the plant, induce local formations of tissue in the shape of more or less wart-like excrescences (Pl. IX, fig. 4).

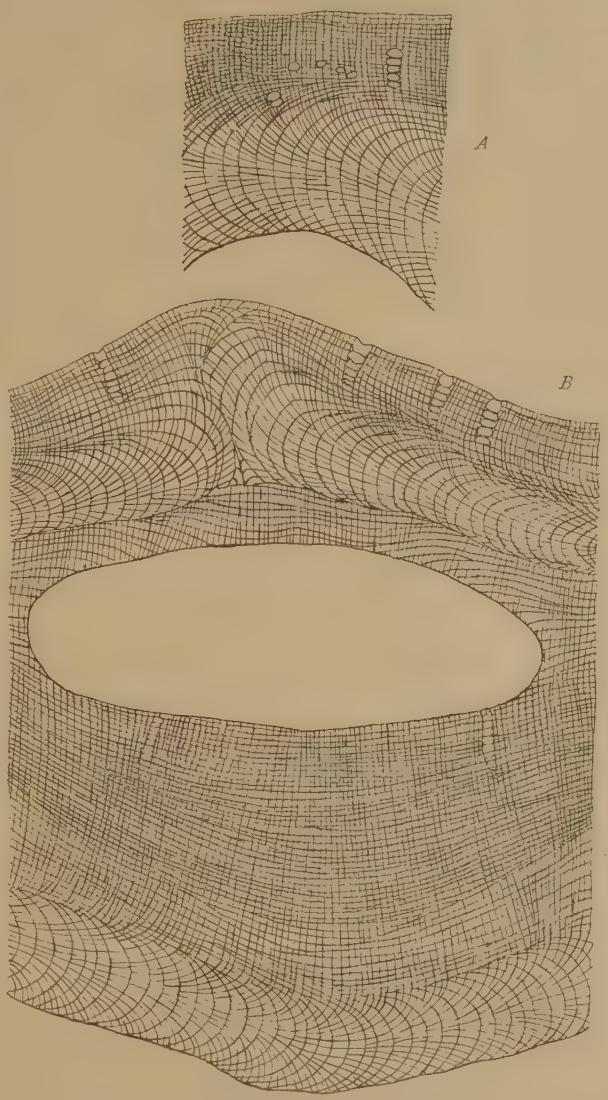

Fig. 19. *Goniolithon Fosliei* (Heydr.) Fosl.
A. Vertical section of the specimen pictured pl. IX, fig. 1;
B. Vertical section of the specimen pictured pl. IX, fig. 2, with a new hypothallium formed over a conceptacle; × 72.

A vertical section of the crust exhibits a rather varying structure, with a vigorous and marked coaxial hypothallium. The perithallic cells are partly squarish, often however with rounded corners, partly vertically elongated and much varying in size, frequently being largest in specimens which are much attacked by animals and attached to an uneven substratum (Fig. 19 *B*). The cells are most frequently thick-walled. New hypothallic formations are often to be seen, particularly developed over damaged parts of the plant. Heterocysts appear in great number, and they form frequently at length grown-in rows. These rows are interpreted by Heydrich as "Zellen der Leitungsschicht". Cp. l. c. p. 59, fig. 1. Similar but much shorter grown-in rows of heterocysts also appear in *Goniolithon frutescens*, although there are frequently to be seen but solitary cells, which in certain specimens are numerous almost in any part of the perithallic layer. In *G. Notarisii* grown-in heterocysts seldom appear. Cp. Solms-Laubach. Corall. Monogr. t. 1, fig. 2.

The cystocarpic conceptacles in this species are scattered almost all over the crust. They appear frequently in a rather great number, but they are, on the other hand, never densely crowded. The conceptacles are subconical, rather low and 800—1100 μ. in diameter, when seen from the surface, sometimes, however, even up to about 1,5 mm., but often not sharply

defined. Antheridia are not yet known with certainty, and as regards the sporangia I refer to the remarks under *G. myriocarpon*.

Occurrence: Also this species appears to be rather widely dispersed, but it apparently never occurs in any great number at the stations above quoted.

Area: Indic: The Maldives and Laccadives; the Red Sea; Zanzibar.

3. *Goniolithon megalocystum* Fosl. mscr. Fig. 20; Pl. IX, fig. 8—9.

Thallus crustlike, convex-concave, 0,3—0,5 mm. thick. Conceptacles of sporangia subconical, low, 1,5—2 mm. in diameter.

Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom.
Stat. 129. Kawio and Kamboling Islands. Karkaralong-group. Reef.

There is known but a solitary typical specimen of this species. It is fragmentary, towards 4 cm. long by a breadth of about 2 cm. There is no evidence that is has been attached, but it forms only a part of a larger specimen which probably has been fastened to some hard object. The crust is convex-concave and approaches in shape one half of the shell of a muscle (Pl. IX, fig. 8). It is about 0,5 mm. thick in the thickest part, plainly decreasing towards the margin which is 0,2—0,3 mm. thick and somewhat rounded off. In the upwards turning part the crust is provided with rather faintly distinctive, concentric ridges, and in the lower part it is concentric striate or shallowly furrowed.

A radial section of the crust exhibits a vigorous hypothallium. The central cells of this layer are 25—35, here and there up to about 40 μ. long, and 10—18 μ. broad, with rather thick walls. It sends forth perithallic rows upwards and downwards, which however are very feeble in the thinner parts of the crust (Fig. 20 *A*). The upper layer increases in thickness towards the thickest part, where it shows an extent of about 200 μ. The cells of this layer are partly squarish, partly vertically elongated, about 10 μ. in diameter, or up to about 18 μ. long. A few heterocysts occur.

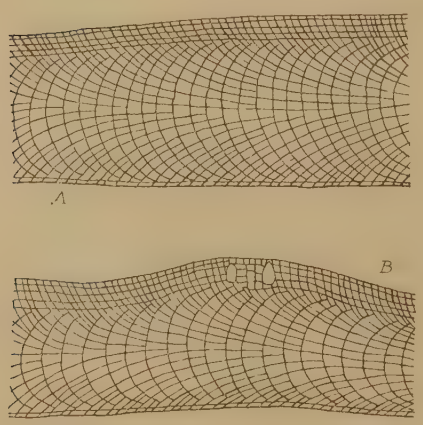

Fig. 20. *Goniolithon megalocystum* Fosl. *A*. Radial section of the type specimen; *B*. Vertical section of the form pictured pl. IX, fig. 9; × 72.

The plant bears a few conceptacles of sporangia in the month of July. They are conical, but low, rather abruptly passing into a short and thick tip, not distinctly defined, 1,5—2 mm. in diameter, when seen from the surface. The sporangia are thinly scattered over the almost plain bottom, 100—140 μ. long and about 60 μ. broad.

With some reservation I refer a couple of somewhat differing specimens to the same species. They not unlikely represent a form corresponding with similar forms of *Lithothamnion fragilissimum* and *L. simulans*. The crust is about 0,3 mm. thick, loosely covering Bryozoa, Squamariaceae, a young *Goniolithon frutescens* and other calcareous algae attached to a coral

(Pl. IX, fig. 9). It bears a few conceptacles of cystocarps which are conical and about 1 mm. in diameter, when seen from above. In structure it coincides in the main with the type of the species (Fig. 20 *B*). What makes it uncertain, however, whether this form in fact belongs to the species in question, is that the cystocarpic conceptacles are considerably smaller than those of sporangia in the type. But the specimens appear to be stunted, and it may be that the said organs are larger in better developed specimens and show the same variation in size as e. g. *Goniolithon Fosliei* and other species. Nor can be judged from a solitary specimen of the type only bearing a few conceptacles of sporangia, whether the latter are as a rule of the quoted size, or perhaps partly smaller. Therefore, there seems at present to be no reason to classify this form as a denominated one, far less as an independent species.

The above species is plainly distinguished from any other species known of this genus. It seems to stand nearest to *G. Fosliei*, but distinguishes itself by essential characteristics. In habit, however, it rather approaches certain forms of *Lithothamnion fragilissimum* and *L. simulans*, and sterile specimens may be easily confounded without closer examination.

Occurrence: As mentioned above, only one specimen is known of the type of the species. It was collected at stat. 129. Of the said differing form two specimens have been brought home from stat. 93.

b. Ramosa (*Cladolithon* Fosl.).

4. *Goniolithon Reinboldi* A. Web. et Fosl. Fig. 21; Pl. X, fig. 1—6.

Lithophyllum Reinboldi A. Web. et Fosl. Three new Lithoth. p. 5.
Lithophyllum Reinboldi Fosl. Lithoth. Mald. et Laccad. p. 466, pl. XXIV, fig. 4.
Syn. Lithophyllum cerebelloides Heydr. in Ber. der Deutsch. Bot. Gesellsch. 1901, p. 405.

Stat. 19. Bay of Labuan Tring, West coast of Lombok. 18—27 m.
Stat. 71. Pulu Barang near Makassar. Reef.
Stat. 78. Lumu-Lumu-shoal, Borneo-bank. 34 m. Coral and Coralsand.
Stat. 79. Pulu Kabala-dua, Borneo-bank. 22 m. Coralsand.
Stat. 91. Muaras-reef, inner side: East coast of Borneo. Lithothamnion-bank near the Island in shallow water.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom.
Stat. 99. Off North-Ubian. 16—23 m. Lithothamnion bottom.
Stat. 125. Off Sawan, Siau Island. 27 m. Stone and some Lithothamnion.
Stat. 193. Sanana Bay, East coast of Sula Besi. Reef.
Stat. 213. Saleyer Island. Reef.
Stat. 234. Nalahia Bay, Nusa-Laut Island. Reef.
Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m.
Stat. 248. Rumah-Lusi, North-point of Tiur Island. Reef.
Stat. 252. West side of Taam Island. Reef.
Stat. 258. Tual, Kei Islands. 8—12 m. Lithothamnion, sand and coral.
Stat. 261. Elat, West coast of Great-Kei Island.
Stat. 282. Anchorage between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.
Stat. 299. Buka or Cyrus Bay, South-coast of Rotti Island. 34 m. Mud, coral, and Lithothamnion.
Stat. 303. Haingsisi, Samau Island. Reef.
Stat. 322. $1^1/_2$ mile south of Tandjong Lajar, South coast of Bawean Island. 32 m. Coral.

In classifying this species l. c. it seemed strange to me that the conceptacles of sporangia, in a section made thin by grinding, were rather differing in shape from those in typically developed specimens of *Lepidomorphum*, one of the two subgenera of *Lithophyllum*. However, I classed it with the latter, as at the time I had not the opportunity for examining it more carefully, nor did I possess good sections. Besides, the conceptacles were smaller than usual in *Goniolithon*, and externally rather resembling those of the genus mentioned above. Afterwards I have had the opportunity of examining a larger material of the plant, and now I consider it to be a *Goniolithon*, although only sporangia are known. The most certain distinguishing feature between the said two genera is owing to the cystocarps. But also the sporangia are differing, in as much as in *Goniolithon* they arise from any part of the disc almost plain or sometimes even faintly cup-shaped, whereas in *Lithophyllum* they arise around the peripherical parts of the disc more or less overarched. Sometimes, however, the subgenus *Lepidomorphum* and the genus *Goniolithon* are not clearly distinguished only on account of the sporangia, as these organs, particularly in the said subgenus, often detach themselves, before or towards maturity, from the bottom of the conceptacle and are then to be found around the walls of the latter. This is especially the case when the conceptacle is small in proportion to the number of sporangia developed. In *Lithophyllum* they often, or rather as a rule, lean against the walls of the conceptacle even before detached from the disc, as now and then seems to be the case also in *Goniolithon*. In addition, heterocysts occur in the genus in question, but in sporangia-bearing specimens of certain species they seem to be very scarce. In *Lithophyllum*, on the other hand, heterocysts do not appear, as far as I have hitherto seen.

In a young stage the plant forms thin crusts on corals or other hard objects (Pl. X, fig. 1). It soon develops excrescences or short branches, the latter, however, only once divided in some of the specimens which I have examined. They are densely crowded and by and by anastomosing, so that only the uppermost part is free (Pl. X, fig. 2—5). In this part they are frequently 4—5 mm. in diameter, sometimes, however, thinner and less confluent (Pl. X, fig. 6). The shape of the plant depends on that of the substratum, in general, however, showing a tendency at length to form roundish balls, which attain a diameter of up to about 8 cm. It often shares substratum with other species, particularly *Archaeolithothamnion erythraeum* and *Lithophyllum Okamurai*, and it now and then grows over, but, on the other hand, it sometimes also becomes overgrown by such ones. Cp. pl. V, fig. 11, where this species is almost covered with *A. erythraeum*. Pl. XI, fig. 16 represents a specimen the greater part of which belongs to *L. Okamurai*, being however confluent with the species in question, which is visible lowest to the left on the picture, or even to the right between the branches of the former. Some of the branches of *G. Reinboldi* are marked with a cross on the picture. Pl. IX, fig. 13 also represents a specimen with a few branches of the species in question, here sharing substratum partly with *L. Okamurai*, partly and especially *Goniolithon laccadivicum*.

A vertical section of the crust shows that the hypothallium is composed of a solitary layer of cells. The latter are vertically elongated, frequently more or less oblique and 15—25 μ. long. The perithallium is thoroughly formed by very irregular cells. They are partly rounded, partly angular, in general 12—25 μ. in diameter, occasionally, however, somewhat vertically

elongated, with thick walls; fig. 21. Here and there appear short hypothallic rows, which have been formed over damaged parts of the plant or foreign bodies. A rather indistinct stratification is to be found, now and then formed by rows of minute cells. Heterocysts are very scarce in the sporangia-bearing specimens in hand; they are seldom overgrown and then appearing in the inner layers of tissue.

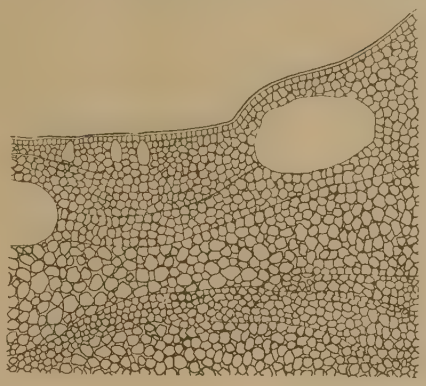

Fig. 21. *Goniolithon Reinboldi* A. Web. et Fosl. Part of a vertical section; × 72.

As mentioned above, sporangia are the only reproductive organs hitherto known in this species. The conceptacles appear in great number almost all over the plant, and they are often so densely crowded that the roofs become angular. They are at first subconical or subhemispherical, with a coarse, but very short tip which soon falls away, at length very low, frequently 350—500, or occasionally up to 700 μ. in diameter, when seen from the surface. The conceptacles by and by become overgrown by new-formed tissue and are to be found in great number in a section. The plant is furnished with these organs almost all the year, but particularly old specimens are often sterile.

This species is easily recognized. In habit it approaches to coarse forms of *Lithophyllum Okamurai* and *L. racemus*, sometimes in this respect not easily distinguishable when sterile. Cp. pl. X, fig. 6 and pl. XI, fig. 14—16. It cannot be confounded with any other species occurring in the Pacific or Indic. But on the other hand it comes near to *Goniolithon Börgesenii* from the West Indies. Of the latter, however, only a few specimens are known. They are rather differing from old specimens of *G. Reinboldi* in habit, but approach to young ones. These two species are hardly distinguishable in structure, but in regard to the conceptacles there is some difference, as the said organs seem frequently to be somewhat larger in the species in question.

Occurrence: Next to *Archaeolithothamnion erythraeum* this species seems to be the most widely distributed one in the Pacific, and apparently in the Indic as well. There have been brought home but a single or a couple of specimens from most of the stations quoted, many of which partly young, partly rather stunted. At some places, however, it occurs in great number and vigorously developed, e. g. stat. 91, but it is uncertain whether the plant forms real banks. It is also known from Pulu Kelamala, east of Pulu Adi, on the north coast of New Guinea, here anastomosed with *Archaeolithothamnion erythraeum*, collected by Prof. A. Wichmann [1]).

Area: South Pacific: Samoa; North Pacific: The Carolines, Sandwich Islands; Indic: The Maldives and Laccadives, Zanzibar, the Mauritius.

5. *Goniolithon laccadivicum* Fosl. Pl. IX, fig. 10—13.

Goniolithon Brassica-florida f. laccadivica Fosl. Lithoth. Mald. and Laccad. p. 469, pl. XXV, fig. 7.

Stat. 91. Muaras-reef, inner side: East coast of Borneo.
Stat. 258. Tual, Kei Islands. 8—12 m. Lithothamnion, sand and coral.

1) The Dutch New Guinea expedition 1902—1903.

Stat. 301. Pepela Bay, East coast of Rotti Island. 22 m. Mud, coral and Lithothamnion.
Stat. 311. Sapeh Bay, East coast of Sumbawa. Reef.

I classified l. c. the plant in question as a denominated form with the following remarks: I have been uncertain whether this plant ought to be considered a form of the above species *(G. Brassica-florida)*, or should be regarded as a separate one. Only two fragmentary pieces are known, and these appear to be rather young. The plant is, however, in several respects closely allied to *G. Brassica-florida*, and, therefore, I place it as a form of the latter until older specimens may be known. It somewhat differs from typical specimens of the species both in habit and structure, but on the other hand it must be borne in mind that *G. Brassica-florida* is a rather varying plant both in habit and even in structure, in the latter respect owing to the fact that it is frequently attacked by lower animals, especially worms, which nearly always show a disturbing influence on the normal development of the layers of tissue.

With some reservation I now place the plant as an independent species. It is certainly not well distinguished from *G. Brassica-florida*, but, according to the material in hand, it is in some respects so far differing that it seems to be entitled to be kept distinct. Thus it is less inclined to form thickened crusts, the consistency is looser, with more regular hypothallic layers in the branches and frequently rather numerous grown-in rows of heterocysts, and the conceptacles of sporangia are as a rule smaller than in the former. However, as I have already remarked in Lithoth. Adriat. Meer., it must also be observed that the mutual relation between *G. Brassica-florida* and *G. mamillare*, a species very nearly allied to the former, has not yet been settled. The species in question seems even to be rather more closely connected with the last named one. It is, therefore, possible that it will prove to be indentic with, or constitutes a form of, *G. mamillare*, or perhaps both will have to be considered as forms of *G. Brassica-florida*. Typically and well developed specimens of the latter species are till now only known from the Adriatic, the Mediterranean and the south coast of Africa. Of *G. mamillare* only a couple of certain specimens are known from Bahia (Brazil), i. e. the types in HARVEY's herbarium, but even these are rather young [1]). Therefore it seems necessary to possess old and well developed specimens from the American coast, in order to be able to settle the delimitation of these three species.

In addition to the description of the species is to be observed that the branches in old specimens are frequently more densely crowded than in the type specimen, the latter and young one pictured pl. IX, fig. 10. The branches more or less anastomose in the lower part, however in less degree than in *G. Brassica-florida*, and the crust does not grow so thick as in the latter, although a new crust sometimes may be developed upon the primary one (Pl. IX, fig. 11—13). The last quoted specimen is confluent with *Lithophyllum Okamurai* and *Goniolithon Reinboldi*. In regard to structure, the medullary hypothallium is more marked than in the said species, the cells frequently being 15—25 μ. long and 10—15 μ. broad, i. e. broader in proportion to the length than in the hypothallium of the crust. Those of the perithallic layer in the branches are often a little smaller than in the perithallium of the crustlike part

1) W. H. HARVEY. Nereis Australis, or Algae of the Southern Ocean. London 1847, p. 109. — As to the occurrence of *Goniolithon mamillare*, according to HARVEY l. c., at Algoa Bay on the south coast of Africa, cp. my remarks in Lithoth. Adriat. Meer.

of the plant, though being here more irregular in size. Heterocysts prove to be rather numerous, and often form grown-in rows. The conceptacles of sporangia, which are the only reproductive organs known, are to be found somewhat scattered in the branches, and often developed in the tips of the latter. They are conical, frequently a little contracted in the middle or upper part, 0,8—1 mm. in diameter, when seen from the surface, and they are of about the same height. Their upper part, more or less elongated, gets dissolved at maturity, and then the conceptacles often become very low, looking rather differing from those in development. The sporangia are four-parted and vary between 100—160 μ. in length by a breadth of 45—60 μ. The plant is, in the area in question, furnished with these organs in the months of January, February, June and December, and at the Laccadives it bears ripe sporangia towards the end of July.

Besides the relation to the species above mentioned, *G. laccadivicum* rather approaches to *G. frutescens* f. *congesta*, and young or somewhat stunted specimens are not easily distinguished. The branches are however coarser and the conceptacles frequently larger, and as regards structure, the cells, particularly those of the medullary hypothallium, are frequently shorter and more thick-walled than in the latter species.

Occurrence: Only one specimen has been brought home from the stations 258, 301, 311, and from stat. 91 a few ones.

Area: Indic: The Laccadives.

6. *Goniolithon frutescens* Fosl.

Calc. Alg. Funafuti, p. 9.

f. *typica* Fig. 22; Pl. X, fig. 7—9.

Foslie l. c.; Lithoth. Mald. and Laccad. p. 468, pl. XXV, fig. 4.

f. *congesta* Fosl. Pl. X, fig. 10—11.

Lithoth. Mald. and Laccad. p. 468, pl. XXV, fig. 5—6.

f. *subtilis* Fosl. mscr. Pl. X, fig. 12—13.

Branches rather densely crowded, subfastigiate, terete, about 1 mm. thick.

Stat. 91. Muaras-reef, inner side: East coast of Borneo. Reef.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom. Sand and coral.
Stat. 220. Pasir Pandjang, West coast of Binongka. Reef.
Stat. 225. South of Lucipara-group. Reef.
Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m.
Stat. 261. Elat, West coast of Great Kei Island. Reef.
Stat. 277. Kulewatti (Sollot) Bay, Dammer Island. Reef.

The specimens in the Siboga collection of the typical form of this species are partly attached to other hard objects, partly they have detached themselves and continued their

growth freely at the bottom. They are however more delicate than those known from Funafuti and the Maldives. The branches too are more elongated and less attenuating upwards, but otherwise agreeing with the said form. Cp. pl. X, fig. 7—9 and Lithoth. Mald. and Laccad. pl. XXV, fig. 4. As to structure it fully coincides with the type, fig. 22.

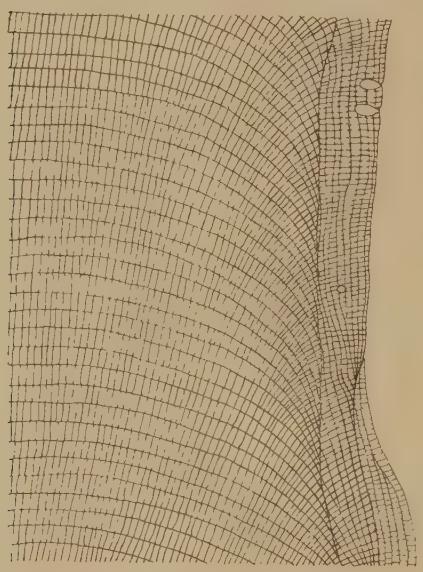

Fig. 22. *Goniolithon frutescens* Fosl. Part of a median section of a branch of the type specimen; × 72.

The form *congesta* in this collection is not quite typically developed, being more irregular, with the branches less fastigiate than in the type specimen from the Maldives. The branches are in this form too a little longer than in the type. Cp. pl. X, fig. 10—11, and Lithoth. Mald. and Laccad. pl. XXV, fig. 5. As mentioned under *G. laccadivicum*, the form in question is sometimes not easily distinguished from the last named species. In habit it also recalls certain forms of *Lithothamnion erubescens*.

The most differing form of the species is however f. *subtilis*. There is a considerable difference in habit between this form and a coarse f. *typica*, and still more it differs from a coarse f. *flabelliformis*, but the latter form does not occur in the Siboga collection. The form *subtilis* is only met with attached to other objects, partly intermingled with filiform algae. It distinguishes itself by rather densely crowded branches, which are partly subdichotomously, partly irregularly divided and very delicate. The latter are terete, with short axes, partly a little attenuating upwards, partly not, and about 1 mm. thick. They often bend themselves downwards, and continuing their growth they come into contact with the substratum or extraneous objects. From the downwards turning tip of a branch is then sometimes developed a small disc-shaped crust on the substratum, or crustlike formations are formed over the said extraneous objects. Besides, the branches now and then anastomose with each other. In regard to structure the form fully coincides with the typical one, but the conceptacles are on the other hand a little smaller. This form much resembles *Lithophyllum byssoides* Lamour in habit, and sterile specimens are hardly distinguishable except as regards structure, in which respect they are, however, quite different.

Occurrence: Only a single and young specimen has been brought home from each of the stations 91 and 93. At stat. 220 have been collected a number of specimens, which partly belong to f. *congesta*, partly form transitions to f. *typica*, or are referable to the latter, but mostly not well developed. A couple of specimens from stat. 240 belong to f. *congesta*, but approach in habit to *G. laccadivicum*. The best developed specimens are from the stations 261 and 277. The form *subtilis* is only known from stat. 225. Thus the distribution of the species has a rather wide range within the investigated area, but is more feebly developed and apparently occurring in less number than at Funafuti and the Maldives.

Area: South Pacific: Samoa, Ellice Islands (Funafuti); Indic: Keeling Islands, the Maldives and Laccadives.

Melobesia Lamour. (Fosl. emend.).

Subgen. Eumelobesia Fosl.

1. *Melobesia subtilissima* Fosl. mscr.

Thallus forming delicate, monostromatic patches of indefinite shape. Conceptacles of sporangia subhemispherical, about 60 μ. in diameter.

Stat. 169. Off Atjatuning, West-coast of New Guinea. Reef.

This species forms delicate patches on *Corallina pilifera*. The patches are partly very small, partly somewhat expanding over the branches of the host, but rarely covering parts of the joints of the latter. The plant is difficult to detect, as it shows the same light colour as the host in a dried stage. The peripherical portions of young specimens are sometimes not confluent, but short subdichotomous rows are formed, which here and there are anastomosing as in *M. farinosa* Lamour. f. *callithamnioides* (Fkbg.) Fosl. mscr. and *M. zonalis* (Crn.) Fosl. The crust is monostromatic except in the neighbourhood of the conceptacles, and it is destitute of cortical cells. I have at any rate been unable to detect such ones in the material in hand. In a surface view the cells are partly squarish, 4—6 μ. in diameter, partly and especially towards the peripheral portions rectangular and 7—9 μ. long. In a vertical section they are also squarish or slightly vertically elongated.

The conceptacles of sporangia appear scattered, and they are on the whole rather scarce. They are subhemispherical and about 60 μ. in diameter, when seen from the surface, with a single orifice. The sporangia are four-parted, about 25 μ. long and 12 μ. broad. The plant bears ripe ones in the month of August.

The species in question comes nearest to *Melobesia rugulosa* Setch. et Fosl. from the coast of California. It is, however, distinguished by essential characteristics, particularly smaller cells and smaller conceptacles.

Occurrence: The plant is only known from the station above quoted, where it seems to occur rather sparingly on the host plant mentioned.

2. *Melobesia farinosa* Lamour.

Hist. Polyp. p. 315; Rosan. Melob. p. 69.

Stat. 40. Pulu Kawassang, Paternoster Islands. On eelgrass [1]).
Stat. 43. Pulu Sarassa, Postillon Islands. On eelgrass.
Stat. 45. 7° 24′ S., 118° 15′.2 E. On *Turbinaria decurrens*. Drifting.
Stat. 53. Bay of Nangamessi, Sumba. On eelgrass.
Stat. 66. Saleyer. On eelgrass.
Stat. 99. North-Ubian. On eelgrass.
Stat. 131. Beo, Karakelang Islands. On *Valonia ventricosa*.

1) By eelgrass I mean phanerogamous plants with long, linear leaves. These leaves may belong either to *Cymodocea*, *Poseidonia* or *Enalis*, three plants of frequent occurrence in the investigated area. Those specimens covered with *Melobesia* were sterile, and they are therefore hardly to be alleged.

Stat. 155. Piapis Bay (Telok Sapira) Northwest coast of Waigeu Island. On *Turbinaria conoides.*
Stat. 163. Seget, West-entrance Selee (Galewo) Strait, New-Guinea. On *Gelidium.*
Stat. 165. North-east side of Daram Island (False Pisangs), East-coast of Misool. On eelgrass.
Stat. 172. Gisser. On eelgrass.
Stat. 184. Kampong Kelang, South-coast of Manipa-island. On eelgrass.
Stat. 213. South Island near Saleyer. On *Laurencia obtusa.*
Stat. 220. Pasir Pandjang, West-coast of Binongka. On eelgrass.
Island Leyden, Batavia. On *Halimeda macroloba,* leg. Dr. BOERLAGE.
Maumeri, Flores. On eelgrass.
Endeh, Flores. On *Laurencia concinna* [1]).
Makassar. On *Sargassum.*
Den Bril, near Makassar. On *Laurencia obtusa* and *Halophila ovalis,* leg. SNACKEY.
Pare-Pare, Celebes. On *Sargassum* and eelgrass.
Birakeke, Celebes. On *Sargassum.*
Balang-Nipa, Celebes. On eelgrass.

This species attaches itself to a number of different other algae as above stated. It bore reproductive organs the time when collected, from the month of April to the end of the year, frequently, however, sporangia and seldom antheridia. The latter organs are developed in conceptacles which are but 60—75 μ. in diameter, when seen from the surface.

Occurrence: The plant seems to occur in rather great number at most of the investigated places.

Area: Common almost everywhere except in the arctic and antarctic regions.

Subgen. Heteroderma Fosl.

3. *Melobesia coronata* Rosan.

Melob. p. 64, pl. IV, fig. 9.

f. *zonata* Fosl.

New Spec. or Forms of Melob. p. 9.

Stat. 81. Pulu Sebangkatan, Borneo-bank. On *Padina.*
Stat. 165. North-east side of Daram Island (False Pisangs), East-coast of Misool. On eelgrass.
Stat. 213. South Island near Saleyer. On *Laurencia obtusa.*
Endeh, Flores. On *Laurencia concinna.*
Den Bril near Makassar. On *Laurencia obtusa,* leg. SNACKEY.

The form of the species considered as typical which underlies ROSANOFF's description l. c., has been found on *Pollexfenia pedicellata* from Australia, according to specimens in LENORMAND's herbarium. An authentic specimen, which I have examined, forms small orbicular, reniform or often crenulate crusts. The latter at length grow more or less confluent. The reproductive organs described by ROSANOFF l. c. as cystocarps are not such ones, but sporangia which are developed in more or less conical conceptacles, with cells as a rule much elongated

1) Where number of station is not quoted, or collector not stated, the specimens have been collected by Madame A. WEBER-VAN BOSSE in 1888—1889. This is also the case with a number of specimens belonging to species of other genera classified in this paper. As they are, however, from the same place, though perhaps not the same localities, as the specimens of the same species collected during the Siboga Expedition, they are not specially mentioned.

around the orifice, forming a corona. These conceptacles are 250—350 μ. in diameter, when seen from above, but they are often not distinctly defined. The sporangia are four-parted, about 75—85 μ. long and 35—40 μ. broad. In other crusts of the same specimen are to be found conceptacles, which are lower or less conical than the above mentioned ones, and the cells of the orifice are not or but a little elongated. They are of about the same diameter as the conceptacles of sporangia, or sometimes a little larger. These are cystocarpic conceptacles, which seem as a rule not to occur in the same crust as those of sporangia; but when several crusts are found on the same substratum, both organs may be met with in the neighbourhood of one another. In the same specimen appear also a few other conceptacles, which are of about the same shape as the cystocarpic ones, but they are only 100—150 μ. in diameter, when seen from the surface. These I suppose to be the conceptacles of antheridia.

With some reservation I refer to the species in question the plant stated above from Borneo bank, forming small, sterile and fragmentary crusts on *Padina*. The crusts are rather brittle and have for the greater part fallen away, so that the original shape is no more to be seen. The plant seems however to belong to *M. coronata* and to be most closely allied to the form *zonata*.

In *Laurencia obtusa* and *Laurencia concinna* from the places above quoted appear some very small crusts in company with *Melobesia farinosa*. They are provided with cystocarpic conceptacles of about the same size and shape as those in typical *M. coronata*, with in part mature carpospores, and the structure coincides in the main with that of the latter. So also in regard to a few crusts, about 1 mm. large, which together with *Melobesia farinosa* are attached to eelgrass. They bear conceptacles which probably are young cystocarpic ones.

The specimens here mentioned are partly too fragmentary, partly too feebly developed to be determined with certainty, especially since the characteristic conceptacles of sporangia are wanting.

According to ROSANOFF l. c., *Dermatolithon pustulatum (Melobesia pustulata auct.)* frequently accompanies *Melobesia farinosa* in the northern temperate zone. It seems, as if the former is, in the area in question, replaced by *Melobesia coronata*, which here apparently now and then accompanies the said species.

Occurrence: The plant seems to occur very sparingly in the places above quoted, and has hitherto not been met with in a well developed stage.

Area: "Australia" (herb. LENORMAND), the type of the species; Indic: South Australia (f. *zonata*).

Lithophyllum Phil. (Fosl. emend.).

Subgen. Eulithophyllum Fosl.

a. Crustacea.

1. *Lithophyllum oncodes* Heydr. Pl. XI, fig. 5—10.

Lithothamnion oncodes Heydr. Neue Kalkalg. p. 6, t. I, fig. 11; ex parte.
Lithophyllum oncodes Heydr. in Ber. der Deutsch. Bot. Gesellsch. 1897, p. 410.

Stat. 91. Muaras-reef, inner side: East coast of Borneo. Reef.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom.
Stat. 181. Ambon. Reef.
Stat. 215. North point of Kabia Island. Reef.
Stat. 225. South of Lucipara-group. Reef.
Stat. 248. Rumah Lusi, North-point of Tiur Island. Reef.

I do not include in this species the form which, according to HEYDRICH l. c., is furnished with cystocarpic conceptacles thus described by him: "Die Cystocarp-Conceptakel sind äusserst selten und bilden auf besonderen Individuen grosse flache und einzelne Erhabenheiten, welche $2^1/_4$ mm. im Durchmesser sind; die Öffnung ist 125—140 μ. gross". This plant cannot be classed with the species in question, but probably represents a species of the genus *Goniolithon*, likely with emptied conceptacles judging from the large orifice mentioned in the quoted description.

When the plant grows on an even or fairly even substratum, it forms an even and smooth crust of a hard consistency. Pl. XI, fig. 5 represents such a specimen from Funafuti almost coinciding in habit with the type specimen l. c. fig. 11. Here the plant becomes vigorously developed, partly forming rather thin crusts on branched corals, partly, and more frequently, a thick coat on lumpy corals or other hard objects. It also sticks to consolidated rock, forming platform or hurricane beach, and attaining a thickness of up to about 1,5 cm., frequently, however, less. The figured specimen shows young and circular crusts developed upon the primary one, and in the upper corner it is confluent with a piece of a coral.

In the Siboga collection occur no specimens so regularly developed as the above mentioned one, but there are a few rather vigorous ones here too (Pl. XI, fig. 9—10). The shape of the crust depends, however, on that of the substratum, as in a number of other and particularly crustlike species, and sometimes the plant even conveys an impression of developing excrescences. Cp. pl. XI, fig. 7, which represents a specimen covering a bucky. In this collection the species in most cases forms more or less irregular and but little expanded crusts in company with other calcareous algae, Bryozoa, small corals and other animals, attached to hard objects of different shape and size, mostly, however, dead corals. Sometimes it forms small cap-shaped crusts on excrescences of corals, together with other algae and sponges, occasionally even recalling a young *Lithophyllum Okamurai* (Pl. XI, fig. 8). The specimen here figured shows a looser consistency than usual in this species, probably owing to the substratum.

As regards structure, the perithallic layer of the plant is thus described by HEYDRICH l. c.: "Die übrige grosse Thallussubstanz wird von keinen bemerkenswerten Schichtungen durchzogen, weshalb man von irgend einer bestimmten Aufeinanderfolge derselben nicht reden kann; ab und zu erscheinen grössere oder kleinere zerstreute Zellen, die aber dem Inneren ein noch unregelmässigeres, aber sehr characteristisches Gepräge verleihen. Die grösseren Zellen sind etwa 8 μ., die kleineren 5 μ. im Durchmesser". — From a specimen distributed by HEYDRICH himself and from vertical sections of other typical specimens I have found the perithallium to be composed of cells which are partly squarish or somewhat rounded, 6—9 μ. in diameter, partly slightly horizontally or, more frequently, vertically elongated and in the latter case up to about 18 μ. long. The cells are now rather thick-walled, now thin-walled. Besides, in this layer of tissue are to be found short horizontal rows of larger cells, partly occurring in great number, partly

rather scarcely, and differing from the other perithallic cells. The number of cells in each row generally varies between 6 and 12. They are in general 18—25 μ. in length by 12—15 μ. in breadth. I cannot with certainty explain the nature of these cells-rows. However, they seem to be foundations of sporangia, which from some reason or other have not become further developed. In a horizontal section of a crust these cells are isodiametric and form clusters about 100 or up to about 150 μ. in diameter. They occur in greatest number in specimens which are richly furnished with overgrown conceptacles of sporangia, but in some parts of a crust they are quite wanting. Similar formations are to be found in *Lithophyllum craspedium*, a species which in structure comes rather near to the species in question. Here too they partly appear in great number, partly they are very scarce.

Some of the specimens in this collection exhibit cells which in part are more regular, more commonly vertically elongated and larger than generally seen in this species. They approach to a form of the species which I have mentioned in Lithoth. Mald. and Laccad. p. 468, but I did not find the difference to be so important as to allow of classifying it as a separate species or form.

The plant is in most cases sparingly furnished with sporangia. It has been collected in the months of June and September—December.

Occurrence: There have been brought home but a couple of specimens or even solitary specimens from stations 91, 93, 181, 215 and 248. This fact seems to indicate that the plant has been scarce in these places. On the other hand it has apparently occurred in great number at stat. 225.

Area: South Pacific: Tami Island on the north-eastern coast of New-Guinea; North Pacific: Ellice Islands (Funafuti), California (San Diego) [1]); Indic: The Maldives and Laccadives, the Mauritius; North Atlantic: West Indies (St. Croix?) [1]).

b. Ramosa.

2. *Lithophyllum Okamurai* Fosl.

Five new calc. Alg. p. 4.

f. *japonica* Fosl. Pl. XI, fig. 13—19.

Det Kgl. Norske Vidensk. Selsk. Skrifter 1900, Aarsberetning.

f. *angularis* Fosl. Pl. XI, fig. 11—12.

Det Kgl. Norske Vidensk. Selsk. Skrifter 1900, Aarsberetning.
Syn. Lithophyllum cephaloides Heydr. in Ber. der Deutsch. Bot. Gesellsch. 1901, p. 271.

Stat. 19. Bay of Labuan Tring, West coast of Lombok. 18—27 m. River-mud, coral, coralsand.
Stat. 91. Muaras-reef, inner side: East coast of Borneo. Reef.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom.
Stat. 99. North Ubian. 16—23 m. Lithothamnion bottom.

1) I am for the present unable to draw any limit between the type of this species and a specimen in hand from each of these places.

Stat. 109. Pulu Tongkil, Sulu Archipelago. 13 m. Lithothamnion bottom.
Stat. 258. Tual, Kei Islands. 8—12 m. Lithothamnion, sand and coral.
Stat. 303. Haingsisi, Samau Island. Reef.

When I classified this species l. c. I considered it to be closely allied to *Lithophyllum fasciculatum*, a species which, however, comes very near to *L. racemus* (Pl. XI, fig. 11). I then possessed specimens only of the form of the species which I have afterwards named f. *angularis* (Pl. XI, fig. 11—12). Simultaneously with the latter I described the form *japonica*, which is strongly resembling *L. racemus* in habit. (Pl. XI, fig. 13). The species includes some specimens which I have formerly considered referable partly to *L. fasciculatum*, partly to *L. racemus*.

I will not here enter more fully upon the question whether this species is in fact specifically distinguished from *L. racemus*, nor on its relationship to other nearly allied species, as *L. Kaiserii* Heydr., *L. pallescens* Fosl. (including *L. californiense* Heydr.), *L. affine* Fosl., *L. fasciculatum* (Lam.) Fosl., and *L. Andrussowii* Fosl. — I have already remarked in Lithoth. Mald. and Laccad. that I keep them distinct until they have been more fully examined in a larger amount of material from different localities. This particularly concerns the first named three species. I regard *L. Okamurai* as an independent species owing to the fact that the cells are as a rule longer in proportion to the breadth than in *L. racemus*. In this respect, however, the species in question can hardly be distinguished from *L. fasciculatum*, the latter hitherto with certainty known only from the west-coast of Ireland [1]). Besides, the conceptacles of sporangia are a little more peripherical than usual in *L. racemus*, although no certain limit is to be drawn in this respect. In addition, among a rather great number of specimens examined from the coast of Japan I met with a single one, in which a part of the lower layers of tissue exibits alternating long and short cells. Such ones have never been seen in *L. racemus*. In this respect the plant approaches to *L. pallescens* from the Pacific coast of America. In the latter species the cells are, however, more frequently alternating long and short, though in such cases often rather irregularly. This is also the case with *L. affine* from the Red Sea. The last named species is partly closely allied to *L. racemus*, partly to *L. pallescens* in structure, whereas in habit it comes near to delicate forms of *L. Kaiserii*, to which it in part also approaches in structure. Therefore, it is necessary to have access to a number of well developed specimens particularly from the Red Sea and from the Pacific coast of America in order to be able to settle the delimitation of the said species or forms [2]).

I have remarked before in this paper that *L. Okamurai* sometimes also recalls other species than the above mentioned ones in habit, species which however in other respects are quite differing. Thus it occasionally comes very near to certain forms of *Goniolithon Reinboldi* as to habit. Cp. pl. X, fig. 6. Now and then it also gets confluent with the latter, as to be seen on pl. XI, fig. 16, where some branches belonging to *G. Reinboldi* are marked with a cross. Besides, pl. IX, fig. 13 represents a specimen which in the main belongs to *Goniolithon laccadivicum*, sharing however substratum with the species in question as well as *Goniolithon*

1) M. Foslie. New or critical calcareous Algae. — Det Kgl. Norske Vidensk. Selsk. Skrifter 1899. nº 3. Trondhjem 1900, p. 30.
2) I intend later on to publish an account of the unarticulated Corallinaceae, with pictures of all the species and forms known to me.

Reinboldi. The plant also approaches in habit to *Archaeolithothamnion erythraeum*, though more seldom, and cannot even in this respect be confounded with the latter except when the specimens are dead, water worn or much bleached. Such a specimen, anastomosed with the said species, is represented pl. XI, fig. 17.

In the Siboga collection the species in question is not well represented except from station 91, where a number of large and well developed specimens have been collected (Pl. XI, fig. 14—16). These specimens belong to f. *japonica*. On the other hand, there occurs no old specimen of f. *angularis*, but only a couple of young ones showing transition to this form. At stat. 303 the species is represented by a delicate form, which partly resembles *Lythophyllum Marlothii* in habit. It is, however, differing from the latter in structure, as the cells are in part even a little longer than commonly seen in *L. Okamurai*. Therefore, I consider it as a somewhat stunted form of this species (Pl. XI, fig. 18—19). The plant in question bears sporangia in the months of February and June, but scantily.

Occurrence: This species has apparently been abundant at stat. 91, the only station in the investigated area where it occurs typically and well developed. From the other stations above quoted have been brought home but a single or a few young, frequently stunted and not always quite certain specimens.

Area: South Pacific: Tami Island on the north-eastern coast of New Guinea; North Pacific: The Pacific coast of middle Japan [1]).

Subgen. Lepidomorphum Fosl.

a. Crustacea.

3. *Lithophyllum Yendoi* Fosl. Pl. XI, fig. 1—4.

New or crit. Lithoth. p. 25.

Stat. 51. Madura Bay and other localities in the southern part of Molo Strait. Shore.
Stat. 61. Lamakera, Solor Island. Reef.
Stat. 86. Dongala, Palos Bay, Celebes. Reef.
Stat. 155. Piapis Bay (Telok Sapira), Northwest coast of Waigeu Island. Reef.
Stat. 181. Ambon. Reef.
Stat. 193. Sanana Bay, East coast of Sula Besi. Reef.
Stat. 240. Banda-anchorage. Reef.

The type specimen of this species is pictured pl. XI, fig. 1. In the area investigated the plant fully coincides with the type from the coast of Japan (Pl. XI, fig. 2—3). As regards structure, however, the cells sometimes prove to be a little larger than the measures given l. c. But there is no great variation in this respect.

When growing on an even substratum, the plant is almost quite even, the crust closely

1) In the British Museum a couple of specimens are kept under the name of *Lithothamnion polymorphum* from the Rodriguez Island in the Indic. They were some years ago placed by myself under *Lithophyllum racemus*. The specimens also come very near to *L. Okamurai* in habit, but are likely to be referred to a densely branched form of *L. Kaiserii*, if as remarked above, the latter is on the whole to be maintained as an independent species. — Cp. George Murray. An Introduction to the Study of Seaweeds. London 1895. Fig. 83 (p. 242).

and firmly adherent to the substratum. But on an irregular substratum it forms more or less uneven and irregular crusts, which little by little become confluent, and sometimes at length look as if developing small excrescences. There are two specimens from stat. 240, one of which is attached to an irregular substratum, apparently some volcanic mass. The crusts of this specimen are very irregular, partly with small excrescences which are, however, owing to the uneven substratum or to the covering up extraneous objects or dead crusts of the same species. The other specimen is quite different in habit from a typically developed specimen, forming numerous and crowded wartlike excrescences or short branches about 1 mm. in diameter. It has been attached to some rather loose and irregular object. Upon the primary and at length anastomosed crusts, extraneous objects have attached themselves, and new crusts have been developed upon the latter. These crusts have been at least partly water worn, and new crusts have again been developed together with another appearance of extraneous objects in a rather irregular way, the crusts of the alga often converging and a little rising, and at length more or less anastomosing, or covering up the said extraneous objects or roughnesses of the subjacent parts. In this way the mentioned excrescences are formed. A vertical section exhibits hypothallic cells which are partly more elongated than frequently to be seen, sometimes even forming a rather vigorous layer of tissue, though the hypothallium is in general slightly developed in this species. The first mentioned specimen belongs without doubt to the species in question, and also the other one is most probably a form of the same species, only peculiarly developed owing to the substratum.

In Lithoth. Adriat. Meer. I have mentioned that particularly *Lithothamnion Philippii* develops partly a vigorous, partly a rather feeble hypothallic layer, depending on the shape and nature of the substratum. The consistency is rather varying too, sometimes rather loose, sometimes firmer than usually met with. A similar condition also appears in *Lithothamnion fruticulosum*, *Goniolithon Fosliei*, *Lithophyllum expansum* and especially *Lithophyllum incrustans*. Under *Lithophyllum oncodes* I mentioned a specimen with comparatively loose consistency, — firm consistency being the general character of the species. The species in question offers a striking instance of a similar state of things. Thus pl. XI, fig. 2 represents a specimen covering a piece of rather hard wood. It is closely adherent to the substratum, although less firmly than if the plant is attached to stones, as e. g. the specimens pictured pl. XI, fig. 1 and 3. However, it does not differ in any essential degree from the latter ones, neither in habit, nor in consistency and structure. On the other hand, the specimen pictured pl. XI, fig. 4 is rather differing in both the latter respects, particularly, however, as to consistency, and in habit it shows a more regular outline than usual. It is attached to a piece of very loose wood, i. e. mangrove *(Rhizophora)*, forming almost circular and thin crusts which are somewhat bleached. The consistency is looser, if not much looser, than specimens developed on a hard substratum. Besides, in a vertical section of a crusts, the hypothallic cells are in part larger than usual in this species, but not elongated or less elongated than e. g. those in the specimens above mentioned from stat. 240. They often form almost rhizoid-like sinuosities or clustered crenules towards the substratum. The perithallic cells are, however, of about the same size and shape as in the typical form, although sometimes a little larger and oftener faintly elongated in vertical direction,

up to about 10 μ. long. The crusts are rather young, but fertile, and similar young crusts are to be found in the form attached to the other piece of wood mentioned. Thus the difference lies principally in the consistency and partly the structure too.

This species is easily recognizable, but, as I have remarked under *Lithothamnion erubescens*, it may be questionable whether the plant is in fact distinguishable from *Lithophyllum decipiens* from the south coast of South America. There are up to the present known but a few specimens of the latter. It seems to be a little differing particularly as to structure. *L. Yendoi* also comes very near to *L. subtenellum* from the southern Atlantic coast of Europe and the western coast of Africa. It is furnished with reproductive organs in the months of April to June, August to September, and in November.

Occurrence: Only one or up to three specimens are known from each station. The plant has been best and most typically developed at the stations 51, 155 and 193.

Area: North Pacific: The Carolines, the Pacific coast of middle Japan and the Gulf of Siam.

b. Subramosa.

4. *Lithophyllum papillosum* (Zan.) Fosl.

Rev. Syst. Surv. Melob. p. 20.
Lithothamnion papillosum Zan. Saggio p. 43 (sine descr.); Hauck, Meeresalg. p. 272, t. II, fig. 4.

f. *Cystosirae* (Hauck) Fosl.

Lithoth. Adriat. Meer.
Melobesia Cystosirae, Hauck l. c. p. 266, t. III, fig. 1, 2, 6.
Melobesia (?) Cystosirae Fosl. Rev. Syst. Surv. Melob. p. 21.

Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion.

As mentioned l. c. I have been unable to draw any true limit between *Melobesia Cystosirae* and *Lithophyllum papillosum*. Therefore, I placed the former as a form of the latter. In the Adriatic the plant sticks to stones or other hard objects, e. g. shells of molluscs or a conglomerate of Serpulides and calcareous sediments. Besides it is fastened to *Cystosira*, exceptionally to filiform algae heaped together, and it has also been met with on the branches of *Lithothamnion fruticulosum*.

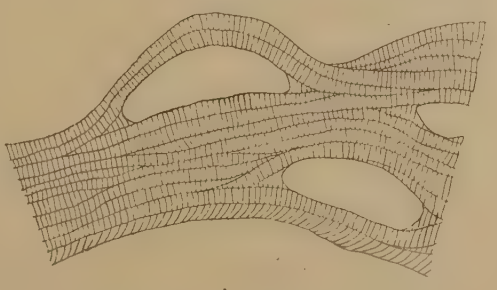

Fig. 23. *Lithophyllum papillosum* (Zan.) Fosl. forma. Vertical section of the crust; × 72.

In the Siboga collection occurs a small and fragmentary, almost quite even crust about 3 mm. in diameter and 0,2—0,4 mm. thick. It sticks to a fragment of a branch of *Archaeolithothamnion* sp. With some doubt I refer this crust to f. *Cystosirae*, to which it agrees in structure. It must, however, be borne in mind that the species in question is much varying in this respect, and the cells are often longer than in the said crust, but often also of exactly the same shape and size. The hypothallium in this species is formed partly by a solitary row of oblique cells, partly

several rows of more elongated cells. The perithallic cells are extremely varying too, from about 12 up to about 60 μ. in length. They are nearly always rather narrow when much elongated, and often comparatively broader when less elongated. In addition, the cells are most irregular when the plant grows on an uneven substratum, and new crusts are formed one above the other, or with numerous new hypothallic formations sometimes being even marked coaxial. Very long cells and short ones are frequently to be seen in one and the same section. In this respect *L. papillosum* to some degree corresponds with *Lithophyllum incrustans*, which exhibits sometimes a very slightly developed hypothallium with rather short cells, sometimes a vigorous hypothallic layer and more elongated cells in the perithallium. This depends on local conditions and the shape as well as partly also the nature of the substratum.

The mentioned crust in this collection bears some emptied conceptacles (of sporangia?). They are of about the same shape and size as in *L. papillosum*, partly, however, a little more prominent, but the value of this character cannot be elucidated from such a scanty material of a much varying form. At any rate, however, there seems to be no reason at present to keep it distinct from the above species.

Occurrence: Only the mentioned small crust is known from the station above quoted.

Area: The Mediterranean and the Adriatic.

c. Ramosa.

5. *Lithophyllum Bamleri* Heydr. Pl. XII, fig. 1.

Corall. in Ber. der Deutsch. Bot. Gesellsch. 1897, p. 412.
Lithothamnion Bamleri Heydr. Neue Kalkalg. p. 4, t. I, fig. 1—3.
Syn. Perispermum hermaphroditum Heydr. in Ber. der Deutsch. Bot. Gesellsch. 1901, p. 409 [1]).

Stat. 79[b]. Pulu Kabala-dua, Borneo-bank. Reef.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor. Shallow water.

I do not hesitate to class with this species a couple of specimens in the Siboga collection. One of them is very small and young. It is attached to a coral, but it shares substratum and is partially covered with a somewhat stunted *Lithothamnion simulans* and another calcareous alga which probably represents a stunted form of *Lithophyllum oncodes*. The other specimen seems also to have been attached at first to some hard object, but has afterwards detached itself. (Pl. XII, fig. 1). In habit both specimens fully coincide with the type. Cp. l. c. t. I, fig. 1—3. But as to structure there is a great difference to judge from the description given by Heydrich [2]). A longitudinal section of a branch is described by him as follows: "Die centralen Zillen bilden nicht, wie bei der vorigen Species, eine lange und eine kurze Reihe, sondern meist zwei lange Reihen von 1 μ. Breite und sehr verschiedenen Längen, meist 4—6 μ., und eine Reihe quadratischer Zellen von nur 1 μ. Grösse. Die Schichtungen kommen also hier durch die Aufeinanderfolge von 2 längeren und einer kurzen Zellreihe zu Stande. Die peripherischen Reihen bestehen aus rundlichen 1—1½ μ. im Durchmesser fassenden Zellen mit dichtem Zellinhalt".

1) F. Heydrich. Die Entwickelungsgeschichte des Corallineen-genus Perispermum Heydrich.
2) F. Heydrich. Neue Kalkalgen von Deutsch Neu-Guinea. (Kaiser Wilhelm's Land)-Bibliotheca botanica H. 41, Stuttgart 1897.

However, an authentic fragment which I have examined is in this respect quite different. Thus in a median longitudinal section of a branch the longer cells of the medullary hypothallium are 27—50 μ., sometimes even up to about 60 μ. in length and 7—12, rather seldom up to 15, but frequently about 10 μ. in breadth. The shorter cells of the said layer are 12—24, or up to 30, mostly 16—20 μ. long. The perithallic layer exhibits cells which are squarish, 6—10 μ. in diameter, or vertically elongated and up to 18, occasionally even up to 24 μ. long. Besides, as to the reproductive organs HEYDRICH states l. c.: "Conceptakel 600—700 μ., oberflächlich, wenig erhabene Wärzchen nur auf der Rückseite der Verzweigungen bildend". On the following page, however, he states: "Conceptakel mit Tetrasporangien habe ich nicht gefunden. Die Cystocarp-Conceptakel bilden äusserlich flache meist 1 mm. im Durchmesser fassende Erhabenheiten mit wenig erhabener Entleerungsöffnung. Die Höhle ist meist 300 μ. lang, 50 μ. hoch. Carposporen oval". On the other hand, according to my own measurements they are but 400—500 μ. in diameter when seen from the surface, subprominent and often not well defined. In a median vertical section they are however of about the size last quoted, though now and then somewhat larger. I will not at present express my opinion whether these organs are cystocarpic, or hermaphroditic, or if the plant in fact is a *Lithophyllum*, which, however, seems to be probable. I shall come back to these questions on some future occasion, and for the present leave them in abeyance, particularly because of lack of opportunity of examining a sufficient large material. A few conceptacles examined were empty.

In comparing the description of the structure of e. g. *Lithophyllum Tamiense* Heydr. l. c. with that of *L. moluccense* Fosl. [1]), both afterwards identified by HEYDRICH himself, it will be seen that his description here is almost as far from being in accordance with the fact as his description as regards the species in question. This is in the main also the case as to *Archaeolithothamnion erythraeum* (*Sp. ptychoides* Heydr.). Cp. FOSLIE. Melob. Arb. Heydr. p. 16. The instances of incorrect description might be continued, but I suppose these instances to be sufficient to support my identification of *L. Bamleri* on a small fragment rather than on the description of the species [2]).

I have above subsumed *Perispermum hermaphroditum* Heydr. under the species in question. Of this plant too I have had the opportunity of examining an authentic fragment [3]). It fully resembles *L. Bamleri* in habit, with in part slightly thicker branches. As to the structure of the former, HEYDRICH states l. c. p. 411: „Im Längsschnitt tritt aber besonders auffallend die fächerförmige Stellung der Zellschichten hervor, die in regelmässig scharf abwechselnden Reihen den Thallus durchziehen. Die einzelnen Zellen eines central gelegenen Fadens

1) M. FOSLIE. Calcareous Algae from Funafuti — Det Kgl. Norske Vidensk. Selsk. Skrifter 1900, n⁰ 1, p. 10.

2) "Nun enthalten leider die Diagnosen vieler Arten nur Angaben über den Habitus; in Folge dessen kommt es recht häufig vor, dass eine sichere Bestimmung erschwert wird, oder dass man sich vor die Möglichkeit gestellt sieht, eine Pflanze mit demselben Recht zu zwei oder drei Species zählen zu können. Wollte man dann die fragliche Pflanze so ohne Weiteres einer dieser Species zutheilen, so möchte dies der Botanik, als einer exacten Wissenschaft, wenig nützen, und der Autor könnte nachher in die unangenehme Lage kommen, dass die nicht beschriebenen Merkmale solcher Species mit denen der von ihm hinzugerechneten Pflanze nicht im Einklang stehen. Es ist daher jetzt unbedingt nothwendig, dass ein Autor, wenn er Prioritätsansprüche erheben will, die Diagnose nicht nur auf den Habitus beschränkt, sondern sie auch auf Zellen und Früchte ausdehnt". HEYDRICH in Ber. der Deutsch. Bot. Gesellsch. 1901, p. 418. — I want to add that it is worse when an author cannot be relied on as to the description, or when he quotes incorrectly.

3) I express my best thanks to Dr. JEAN CHALON, who has shown me the favour to spare me a part of a specimen of this species as well as a couple of other ones distributed by HEYDRICH himself.

wechseln mit kurzen von 14 μ. Breite und 20 μ. Länge und langen, von gleichfalls 14 μ. Breite, aber 40 μ. Länge regelmässig ab. Nach der Peripherie zu bleiben sie sich dann in der Grösse gleich. Die oberen Zellen enthalten 1—3 längliche, kaum 2 μ. grosse Chromatophoren; dagegen schliessen die langen mittleren Zellen bis 80 kleine, kaum $^1/_8$ μ. (!) grosse Chromatophoren ein". It would seem from what is quoted that the cell-rows might be alternating one long and one short, as in *Lithophyllum moluccense*, but in fact they are alternating exactly as in *L. Bamleri*, i. e. usually two long and one short row (Fig. 24). This alternation is however not always regular, as in one and the same section sometimes can also be found now a few long rows, now one long and one short. As to the size of the cells the plant also fully coincides with *L. Bamleri*, i. e. my measurements stated above. A few conceptacles of sporangia occur in the said fragment. They are convex, but little prominent, 400—500 μ. in diameter, when seen from the surface. The sporangia are four-parted, 55—70 μ. long and about 30 μ. broad. These organs mainly coincide in shape and development with the genus *Lithophyllum*, and they are similar to those in *L. Bamleri*. I have certainly not seen the sexual organs in *Perispermum*. There cannot, however, be any doubt that those mentioned by HEYDRICH l. c. are identic with the cystocarps described by him under *L. Bamleri*. In addition, it is a significant fact that he l. c. compares *P. hermaphroditum* with eight other species, several of which are very distantly related, but not with *L. Bamleri*, which he received even from the same spot as *P. hermaphroditum*.

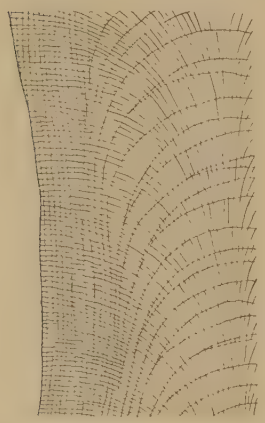

Fig. 24. *Perispermum hermaphroditum* Heydr. Part of a median section of a branch; × 72.

I place the two specimens in this collection under the species-name first given to the plant, but as above remarked, I will not here enter more nearly upon the question whether the species perhaps represents a separate genus. The organs considered as cystocarpic conceptacles certainly seem to be somewhat differing from those in typically developed species of *Lithophyllum*, but it is very uncertain whether the value of this difference is of such importance as to justify the classification of a new genus. In some respect they come near to those in *Goniolithon* too. As for *Perispermum*, however, HEYDRICH bases this genus on hermaphroditic sexual organs, which is no generic character. Besides, he states the formation of the procarp as a co-ordinate character, which he also applies to other genera. I have formerly mentioned the value of the latter as very uncertain, and in this respect I here refer to FALKENBERG's important work on the Rhodomelaceae [1]). His remarks are in the main also applicable to the

1) P. FALKENBERG. Die Rhodomelaceen des Golfes von Neapel und der angrenzenden Meeres-Abschnitte. — Fauna und Flora des Golfes von Neapel. 25. Berlin 1901. — As for the mentioned relation he states as follows p. 103:

"So characteristisch für die ganze Familie der Rhodomelaceen der Bau des Procarps und dessen Entwicklung zum Cystocarp sich gestaltet, die in ihren grossen Umrissen constant festgehalten werden, so mannigfache Varianten können daneben in Einzelheiten auftreten: in der Bildung accessorischer Ästchen durch die fertile Pericentralzelle neben dem Carpogonast, in dem Abort dieser Ästchen oder ihrer Entwicklung zu sterilen Fadenbüscheln, in dem Grade der Fusionirung der Cystocarpzellen. Es liegt nahe, diese Charactere nun zur weiteren systematischen Gliederung der grossen Familie zu verwenden. Dass es zum Theil schwer constatirbare Charaktere sind, würde ihrer praktischen Verwendbarkeit zwar Schwierigkeiten in den Weg legen, ihr wissenschaftlicher Werth würde aber dadurch ja nicht älterirt. Von dem Versuch, auf sie Unterfamilien zu begründen, habe ich aber früh Abstand genommen, weil durch ihre Verwendung Formen von zweifellos nächster Verwandtschaft in unnatürlicher Weise hätten aus einander gerissen werden müssen, und diese Schwankungen in Einzelheiten mehr den Charakter unwesentlicher Zufälligkeiten tragen.

Corallinaceae [1]). HEYDRICH further states that the development of the cystocarpic conceptacles is quite different from that of *Sphaeranthera*, a genus based by him upon the type of *Lithothamnion Philippii* Fosl. (*Lithophyllum decussatum* Solms, nec Phil.). I have however shown in Lithoth. Adriat. Meer [2]) that this genus with its single species (*Sph. decussata*) comprehends at least two different algae [3]) and that the antheridia described by him have nothing to do with the type of the species [4]). For these reasons I keep the species in question provisionally at least under the genus *Lithophyllum*.

Occurrence: The two specimens above mentioned are from stat. 282. Afterwards, however, I met with a small but rather well developed specimen from stat. 79b.

Area: South Pacific: The Tami Island on the north-eastern coast of New Guinea.

6. *Lithophyllum moluccense* Fosl.

On some Lithoth. p. 12; Calc. Alg. Funafuti, p. 10; New Melob. p. 12.

f. *typica*. Fig. 25—26; Pl. XII, fig. 2—4, 6, 8.

FOSLIE. Melob. Arb. Heydr. p. 24.

f. *flabelliformis* Fosl. Pl. XII, fig. 5, 9—10.

Melob. Arb. Heydr. p. 24.

f. *pygmaea* (Heydr.) Fosl. Pl. XII, fig. 7, 12—13.

Rev. Syst. Surv. Melob. p. 16; Melob. Arb. Heydr. p. 24.
Lithothamnion pygmaeum Heydr. Neue Kalkalg. p. 3, t. I, fig. 8—10.
Syn. Lithothamnion Tamiense Heydr. l. c. p. 1, t. I, fig. 4—7.

Stat. 47. Bay of Bima; near southern fort. Shallow water.
Stat. 78. Lumu-Lumu-shoal, Borneo-bank. 34 m. Coral and coralsand.
Stat. 91. Muaras-reef, inner side: East coast of Borneo. Lithothamnion-bank near the islands, in shallow water.
Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion-bottom. Sand and coral.
Stat. 129. Kawio and Kamboling Islands, Karkaralong-group. Reef.
Stat. 131. Beo, Karakelang Islands. Reef.
Stat. 149. Fau Island, lagune. West coast of Gebé Island. Shallow water.
Stat. 193. Sanana Bay, East coast of Sula Besi. Reef.

Diesen Resultaten entsprechend hat auch SCHMITZ darauf verzichtet, für die Abgrenzung der Unterfamilien der Rhodomelaceen irgend wie auf den Bau der Procarpien oder Cystocarpien zurückzugreifen. Wenn in den Gattungsdiagnosen von ihm regelmässig der Bau der Cystocarpwand und der Gonimoblasten berücksichtigt wird, so geschah das mehr der Uniformität wegen, zu der die Darstellungsweise der übrigen Familien drängte, als dass er selbst besonderen Werth auf den Bau der Cystocarpien gelegt hätte".

1) As regards the cystocarps as a generic character, I have in Rev. Syst. Surv. Melob. applied these organs in about the same sense as indicated by SOLMS-LAUBACH, Corall. Monogr. p. 53 and 64. This character seems to me to be well marked and as a rule easily ascertainable.

2) Wissensch. Meeresuntersuchungen, Abt. Helgoland. — The paper was sent to be printed in the autumn 1902, but owing to unforeseen circumstances it has not yet been printed (March 1904).

3) *Lithothamnion Philippii* and probably young, but fertile specimens of *Goniolithon Brassica-florida*.

4) Cp. M. MÖBIUS in JUST's Botanischer Jahresbericht XXIX (1901). Berlin 1903, p. 305: "Die „Antheridien", ebenso unvollkommen beschrieben, wie abgebildet, dürften wohl Parasiten sein".

Stat. 213. Saleyer Island. Reef.	
Stat. 220. Pasir Pandjang, West coast of Binongka.	Reef.
Stat. 240. Banda. Lithothamnion-bank in 18—36 m.	
Stat. 248. Rumah Lusi, North-point of Tiur Island.	Reef.
Stat. 282. Between Nusa Besi and the N.E.-point of Timor.	Shallow water.
Stat. 311. Sapeh Bay, East coast of Sumbawa.	Reef.
Stat. 313. East of Dangar Besar, Saleh Bay.	Reef.

This species was, among some other ones, classified by myself without mentioning the structure, which was however afterwards described l. c. For this reason, HEYDRICH remarks in Ber. der Deutsch. Bot. Gesellsch. 1901, p. 419, stating the fact that *L. moluccense* and *L. Tamiense* are identic: "Da diese Pflanze nun erst nachträglich vom Autor sicher gekennzeichnet ist, so gehört nicht FOSLIE, sondern mir die Priorität, denn ich hatte zwei Jahre früher *Lithophyllum Tamiense* so ausgiebig beschrieben, dass ein Verwechseln mit einer anderen Species nicht stattfinden konnte; dies war aber bei der FOSLIE'schen ersten Beschreibung recht wohl möglich". Cp. l. c. p. 418. However, if a provisional description of a plant without description of the structure should induce the consequence indicated by HEYDRICH, several species could be disregarded, among these even species described by HEYDRICH himself. Besides, in Melob. Arb. Heydr. p. 17 I have proved that the description of *L. Tamiense* is quite incorrect as to structure. This seems to me to be a matter of deeper regret than a not complete description of a species. Cp. above under *Lithophyllum Bamleri* and *L. oncodes*. The type specimen from the Moluccas is represented fig. 25.

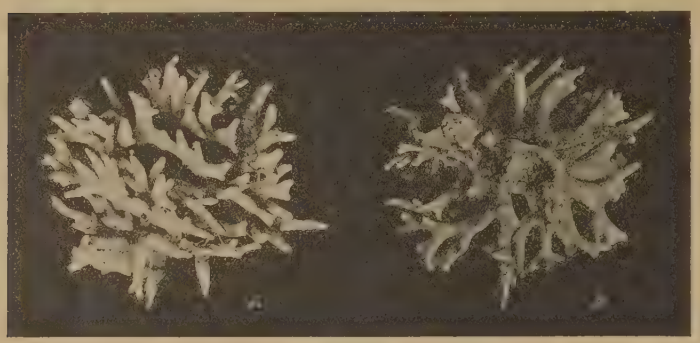

Fig. 25. *Lithophyllum moluccense* Fosl.
The type specimen (Herb. M. MÖBIUS);
A seen from above; *B* seen from below; nat. size.

In regard to the forms of the species I here omit f. *unispinosa* Heydr. Cp. l. c. p. 1, t. I, fig. 4. This form no doubt only represents fragments of old specimens particularly of the typical form. In addition, as to the form described by HEYDRICH as the typical one I remarked l. c.: "Ich nehme *L. moluccense* f. *typica* in einer anderen Bedeutung als HEYDRICH l. c. *(L. Tamiense)*, indem ich zu dieser Exemplare mit runden, subdichotomen oder unregelmässigen Zweigen rechne, während ich für die dichotom-fächerförmige Form, welche HEYDRICH l. c. f. *typica* benennt, den Namen *flabelliformis* vorschlage, entsprechend ähnlichen Formen bei einer Reihe anderer Arten". Consequently I also here class these forms in the sense quoted. Of the form *pygmaea*, described by HEYDRICH l. c. as an indepentent species, I have certainly not seen any authentic specimen [1]). On the other hand, I have had the opportunity of examining a specimen from the Mauritius, which HEYDRICH afterwards also classed with his *L. pygmaeum*. But, as I have shown in Melob. Arb. Heydr. p. 23, this specimen cannot be identic with

1) It seems to me that fig. 10 l. c. only represents a young specimen of f. *typica* or f. *flabelliformis*.

f. *pygmaea* in the sense first taken, if his description is correct, being on the contrary a typical *L. torquescens* Fosl. Referring to my remarks l. c. I do not think to be wrong as to the apprehension of the said form. As regards *L. torquescens* I stated l. c. p. 24: "Es ist möglich, dass auch *L. torquescens* sich blos als eine Form von *L. molluccense* herausstellen wird, aber nach dem vorliegenden Material kan dies zur Zeit nicht mit Bestimmtheit entschieden werden. Unter allen Umständen ist es nicht identisch mit f. *pygmaea*". Having now seen a great number of specimens of the species in question, I consider *L. torquescens* to be only a form of this species. It is not represented in the Siboga collection, but there are specimens which form transition to it. Cp. pl. XII, fig. 11. This form is characterized by very short branches which are thick at the base, and rather attenuating upwards. It somewhat recalls coarse forms of *L. byssoides* in habit. As to structure it also proves to run into the species in question.

The forms *typica* (pl. XII, fig. 2—4, 6—8) and f. *flabelliformis* (pl. XII, fig. 5, 9, 10) are but very little differentiated, one often showing transition to the other. Cp. pl. XII, fig. 6, representing an old specimen of f. *typica*, partly however showing transition to f. *flabelliformis*. The form *pygmaea* is distinguished by its branches rather uniform in thickness and thinner than in the other forms. (Pl. XII, fig. 7, 12, 13). It partly runs into f. *typica*, partly shows transition to f. *torquescens*. This form on the other hand corresponds with *Goniolithon frutescens* f. *subtilis* in habit. Cp. pl. X, fig. 12—13. It can even be confounded with the latter if it is not more closely examined. The consistency is however firmer and the structure quite different viewed apart from the reproductive organs.

As to the structure of this species I refer to my descriptions l. c. I will only add that the cells prove to be more varying in size than formerly known, sometimes being thoroughly large (fig. 26 *A*), sometimes rather small (fig. 26 *B*). This variation in structure appears however in part to depend on local conditions.

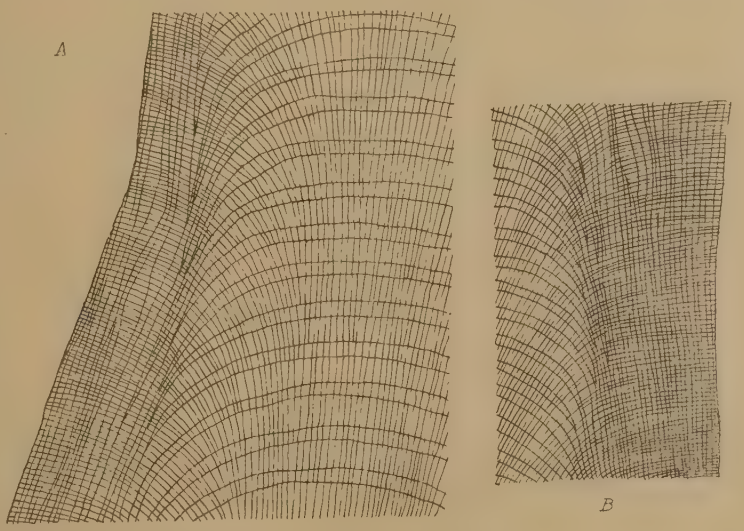

Fig. 26. *Lithophyllum moluccense* Fosl.
A. Part of a median section of a branch of the type specimen;
B. Part of a median section of a branch exhibiting smaller cells; × 72.

The plant is apparently always at first attached to other hard objects, particularly corals, but afterwards it sometimes detaches itself from the substratum. If the object is small, it becomes often at length fully encompassed by the plant. However, broken or loosened branch-systems especially of rather young specimens seem as a rule to continue their growth freely, conveying the impression of having been freely developed at the bottom (Pl. XII, fig. 2). The plant is often rather burdened with foreign bodies which however seem to be of less importance to a normal development than in several other species. It is furnished with reproductive organs in the

months of January and February, and from June to the end of the year, but in the specimens collected they most frequently occur in small number.

Occurrence: The species has apparently occurred abundantly at the stations 91, 220 and 240, perhaps also at most of the other stations, from which, however, partly only one, partly a few specimens have been brought home. Nearly all the specimens from stat. 220 belong to f. *pygmaea*, whereas at the other stations only f. *typica* has been represented, now and then with scattered specimens of f. *flabelliformis*.

Area: Pacific: The Moluccas, the Carolines, Tami Island on the north-eastern coast of New Guinea, and at Queensland; Indic: the Mauritius (f. *torquescens*).

III. Mastophoreae Fosl.

Mastophora (Decsn.) Harv.

Subgen. Eumastophora Fosl.

1. *Mastophora macrocarpa* Mont. Pl. XIII.

Voy. au Pol. sud. p. 149; Aresch. in J. Ag. Spec. Alg. II, p. 528; Kütz. Tab. Phyc. VIII, t. 100.
Syn. Mastophora macrocarpa Heydr. in Hedwigia. Bd. 33 (1894), p. 300?

Stat. 58. Seba, Savu.	Reef.
Stat. 115. East side of Pajunga Island, Kwandang Bay.	Reef.
Stat. 125. Sawan, Siau Island.	Reef.
Stat. 129. Kawio and Kamboling Islands, Karkaralong-group.	Reef.
Stat. 149. Fau Island, lagune. West coast of Gebé Island.	Reef.
Stat. 193. Sanana Bay, East coast of Sula Besi.	Reef.
Stat. 231. Ambon.	Reef.
Stat. 279. Rumah-Kuda Bay, Roma Island.	Reef.
Stat. 303. Haingsisi, Samau Island.	Reef.
Birakeke, Celebes [1]).	
Den Bril near Macassar. leg. Snackey.	

The Kützing figure of this species in Tab. Phyc. l. c. is a fairly exact representation of the plant occurring under that name in the Kützing herbarium, now in the possession of Madame Weber-van Bosse. The specimen is authentic, having been distributed by Montagne himself. In addition to the description of the plant is to be stated that the conceptacles of sporangia in the said specimen are conical and about 750 μ. in diameter, when seen from above.

In the Siboga collection occur a number of specimens which fully agree with the said type specimen. The plant partly covers and rather closely clings to different other algae (pl. XIII, fig. 1—5, 7, 9), partly at length the greater part of it gets free (pl. XIII, fig. 6, 8, 10—12), or it may be loosely creeping over the bottom, to judge from the sand or other extraneous

1) Cp. the footnote 2 under *Melobesia farinosa*.

objects with which many specimens are burdened in the lower part. It is attached to the substratum with a larger or smaller number of rhizoids, which also is the case with the lowest part of e. g. *M. Lamourouxii*. It often comes near to certain forms of this species in habit. The thallus, however, is thicker, more uniform in breadth and less broadening upwards, and the conceptacles are much smaller. Those of sporangia often occur in rather great number, varying between 700 and 800 μ. in diameter. The sporangia are four-parted, 250 (200)—350 μ. long and 150 (120)—200 μ. broad. In a couple of specimens occur a few conceptacles of about the same diameter as the last mentioned ones. They are however very low and provided with a rather elongated tip. I am not sure whether they represent young conceptacles of sporangia or perhaps are cystocarpic ones. Similar, but larger, conceptacles are met with in very small number in *M. Lamourouxii* too. The plant bears sporangia, partly however scantily, in the months of February, April, and July—November.

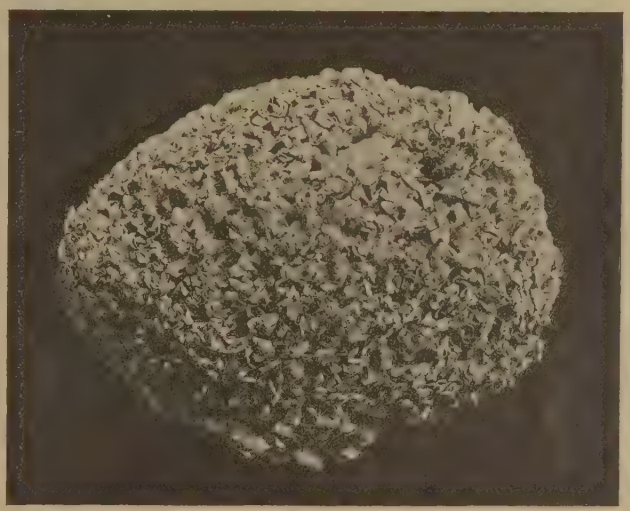

Fig. 27. *Mastophora macrocarpa* Mont., forma.
Specimen forming a globular-ovoid mass; stat. 193; nat. size.

A peculiar form of the species from stat. 193 is represented fig. 27. It forms a globular-ovoid mass densely heaped together and somewhat curled in the upwards turning part. It is furnished with a few conceptacles of sporangia agreeing with those in the typical form. This specimen corresponds with certain forms of *Corallina officinalis* which sometimes occurs in almost similar masses, when growing in much exposed localities and not sheltered by other algae. The form in question seems to have risen in the same way. Madame A. Weber-van Bosse kindly informs me that many algae at that station, e. g. *Gracilaria*, assumed a similar shape, she supposes owing to the heavy swell that broke on the reef.

Occurrence: The species seems to be commonly dispersed over the greatest part of the Malay Archipelago.

Area: North Pacific: The Marianne Islands, Formosa [1]).

2. *Mastophora affinis* Fosl. mscr. Fig. 28—29.

Thallus coriaceous-membranceous, crustily covering *Polyopes constrictus*. Conceptacles of sporangia conical, 1—1,2 mm. in diameter.

Sikka, Island of Flores.

This plant crustily covers or encompasses the branches of the named host, partly but

1) With some doubt I class with this species the plant from Formosa mentioned by Heydrich l. c. He states that "die Conceptakel sind ausserordentlich gross über die ganze Oberfläche verbreitet".

loosely covering, partly rather closely clinging to the latter. It is attached with numerous rhizoids. New crusts are now and then formed upon the primary one, or covering foreign bodies which have attached themselves to the plant and then partly also extended over the primary crust, sometimes at length rather irregularly developed and a little curled (Fig. 28). The crust here and there grows free, but it does not form divided branches. It is very brittle in a dried stage. A vertical section of the plant exhibits cells which are rectangular, 50—100 μ. long and 15—35 μ. broad (Fig. 29). The conceptacles of sporangia are conical, 1—1,2 mm. in diameter, when seen from above. A few sporangia examined were young, indistinctly four-parted and 160—200 μ. in length by 80—100 μ. in breadth. The plant is furnished with these organs in the month of December.

Fig. 28. *Mastophora affinis* Fosl.
Crustily expanding over the branches of *Polyopes constrictus*; nat. size.

Although there are some species of this genus which are unsufficiently known and hardly recognizable from the descriptions, I venture to place the plant in question as an independent species, having been unable to identify it with any formerly described one. In habit it closely approaches to young specimens of *M. macrocarpa*, but, as far as hitherto seen, it does not form branches, though it shows a tendency to divide itself. *M. macrocarpa*, on the other hand, forms branches in a stage as young as the specimens known of *M. affinis*. In a section the cells of the latter species are larger than those of the former one. However, the most certain distinguishing feature lies in the conceptacles of sporangia. I have measured numerous conceptacles in *M. macrocarpa* from different places, but I have not met with larger ones than about 800 μ. in diameter. In the species in question, on the other hand, they are of the size stated above and about as large as in *M. Lamourouxii*. Therefore, the plant seems to be well defined from *M. macrocarpa* and cannot, at present at least, be considered as a form of this species. In several species, particularly of other genera, the conceptacles are certainly much varying in size which, however, does not seem to be the case in the here mentioned ones. *M. Lamourouxii* in a young stage apparently never extends itself so crustily as *M. affinis*, and the thallus is thinner. The conceptacles of sporangia in *M. Lamourouxii* vary between 1,1 and 1,3, seldom up to 1,4 mm. in diameter, and they

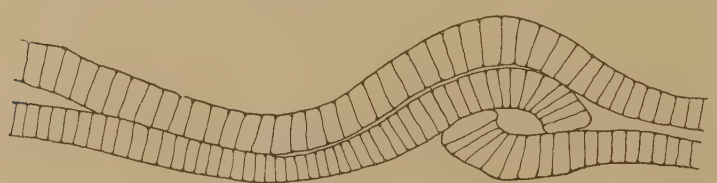

Fig. 29. *Mastophora affinis* Fosl.
Vertical section of the crust; × 72.

are perceptible in the lower part of the thallus too, i. e. the bottom of the said organs is here very slightly convex and marked by a faintly impressed annular border. This is never seen in *M. affinis*, nor in *M. macrocarpa*. Besides, older specimens of *M. Lamourouxii* are quite different. The species in question also comes near to *M. pacifica*, which however is more delicate, with smaller conceptacles [1]).

Occurrence: Only the three specimens figured are known from the station quoted above.

Subgen. Lithoporella Fosl.

3. *Mastophora melobesioides* Fosl. Fig. 30—32.

Det Kgl. Norske Vidensk. Selsk. Skrifter 1902, Aarsberetning (Trondhjem 1903).

Stat. 66. Bank between islands of Bahuluwang and Tambolungan, south of Saleyer. 8 to 10 m. Dead coral; Halimeda; Lithothamnion. — The species in question overgrown by *Lithothamnion fruticulosum*.

Stat. 81. Pulu Sebangkatan, Borneo-bank. 34 m. Coral bottom and Lithothamnion. — Partly uncovered, partly overgrown by *Lithothamnion prolifer* and *Archaeolithothamnion erythraeum*.

Stat. 93. Pulu Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago. 12 m. Lithothamnion bottom. Sand and coral. — Overgrown by *Archaeolithothamnion erythraeum*.

Stat. 106. Kapul Island, Sulu Archipelago. 13 m. Coral bottom. — On *Lithothamnion fruticulosum*.

Stat. 109. Pulu Tongkil, Sulu Archipelago. 13 m. Lithothamnion bottom. — Partly uncovered, partly overgrown by *Lithothamnion fruticulosum*.

Stat. 123. North Bay, Biaru Island. 36—27 m. Stone and Lithothamnion bottom. — Overgrown by *Lithothamnion fruticulosum*.

Stat. 133. Lirung, Salibabu Island. Shallow water. — The species in question uncovered.

Stat. 240. Banda-anchorage. Lithothamnion bank in 18—36 m. — Overgrown by *Lithothamnion fruticulosum*.

Stat. 282. Between Nusa Besi and the N.E.-point of Timor. 27—54 m. Sand, coral and Lithothamnion. — Overgrown by *Lithothamnion fruticulosum*.

Stat. 303. Haingsisi, Samau Island. Reef. — Uncovered.

Stat. 315. East of Sailus Besar, Paternoster Islands. Up to 36 m. Coral and Lithothamnion. — Overgrown by *Archaeolithothamnion timorense*.

Stat. 322. $1^1/_2$ mile south of Tandjong Lajar, South-coast of Bawean Island. 32 m. Coral. — The species in question overgrown by *Lithothamnion simulans*.

I classed this species l. c. as a subgenus, *Lithoporella*, distinguished from *Eumastophora* by its irregularly crustlike, undivided and not flexible thallus which is frequently stratified, i. e. one layer of cells with marginal growth on the other.

The plant forms scaly patches or smaller or larger crusts of indefinite shape which frequently get confluent and at length form partly small, partly even extended incrustations on other calcareous algae, Bryozoa, corals and other hard objects, although it has not yet been

1) In Melob. Arb. Heydr. p. 19 I remarked in regard to *Melobesia pacifica* Heydr.: "Es ist klar, dass diese Alge keine *Melobesia* ist, dagegen wahrscheinlich ein neues Genus der Squamariaceen repräsentiert; aber dieselbe als solches aufzustellen scheint zur Zeit doch nicht berechtigt, da ihre Reproduktionsorgane zu wenig bekannt sind". However, in Vidensk. Selsk. Skrifter 1902, Aarsberetning (Trondhjem 1903) I have shown that the plant is a *Mastophora* and placed it as *M. pacifica* (Heydr.) Fosl. — Besides, I remarked that "ältere Teile vom Thallus aus mehreren Zellreihen bestehen". This is however so to be understood that new formations sometimes are developed, one row upon the other, although the cells in certain parts of the thallus can be divided even in vertical direction.

met with on stones (Fig. 30). The crust clings closely and in general rather firmly to the substratum, here and there however but loosely covering the latter and then developing few and short rhizoids. Small crusts are formed partly by a solitary layer of cells, partly, and most frequently, by several ones, which is the case particularly when the plant forms extended crusts. Such crusts attain a thickness of up to about 2 mm., composed of numerous smaller or larger layers of cells, one upon the other, partly anastomosed with the subjacent, partly not and, therefore, showing a more or less scaly or irregular surface. The plant often alternates with other calcareous algae, or animals, or it is rather mingled with divers foreign bodies which have been overgrown here and there in the layers (Fig. 31). Therefore, the shape of the crusts depends on that of the substratum, and the layers are in most cases very irregularly formed on each other.

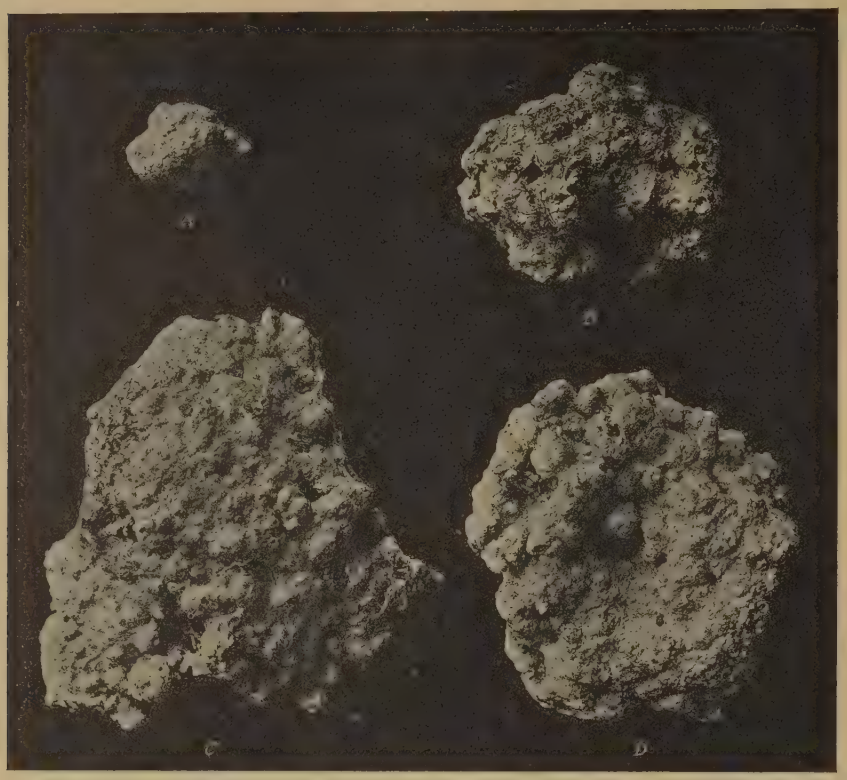

Fig. 30. *Mastophora melobesioides* Fosl.
A. The type specimen from the Maldives; *B*, *C*, *D*. Specimens almost fully covering dead corals and other calcareous algae; Stat. resp. 303, 133, 81; nat. size.

In a vertical section of the crust the cells are shown to be somewhat varying in size, partly large, partly rather small even in one and the same section. Thus fig. 31 *A*. exhibits mostly large cells, about the largest ones which occur in this species, but in other parts of the same section occur cells which are in part even a little smaller than those represented in fig. 31 *B*. They are always vertically elongated, seldom nearly squarish, with thick walls and usually a little rounded corners, varying between 30 and 60, or up to about 75 μ. in length and 15(12)—25, or up to 30 μ. in breadth.

The conceptacles of sporangia, which are the only reproductive organs known, occur scattered. They are superficial, conical and generally 0,8—1 mm. in diameter, when seen from the surface. The sporangia are four-parted, 180—250 μ. long and 100—150 μ. broad. The conceptacles frequently at length become dissolved, leaving a more or less distinct scar which, however, soon gets effaced. But sometimes new crusts partially extend themselves over the conceptacles even before the latter are fully developed, or occasionally quite cover such ones which are emptied and partly undissolved, partly being in a state of dissolution. Therefore,

in sections can now and then be found conceptacles or parts of such ones which are overgrown. The plant bears sporangia in the months of February, June and July.

This species is apt to be overgrown by other calcareous algae and, therefore, it is more frequently found covered than uncovered. It is, however, easily recognizable even in a sterile stage. In habit it partly recalls certain forms of *Melobesia*, partly crustlike Lithothamnia, sometimes rather approaching to e. g. young specimens of *L. simulans*, though this species is forming more even crusts. Besides, fertile specimens recall crustlike forms of *Goniolithon*, to which genus the plant is nearly related. Otherwise it comes nearest to *Mastophora pacifica*, but the latter species shows mostly longer cells and also differs in other respects.

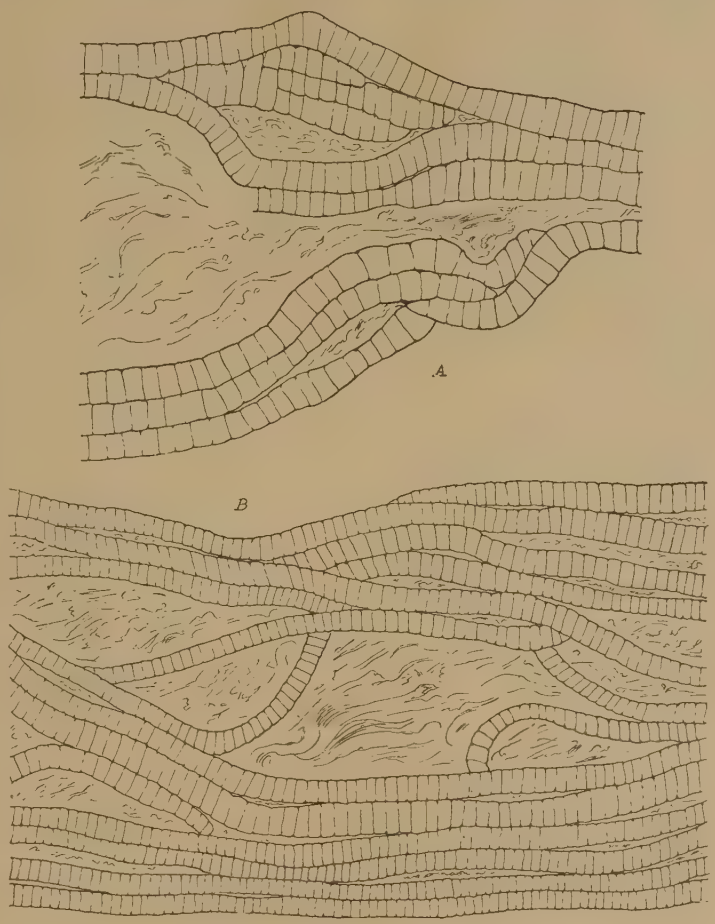

Fig. 31. *Mastophora melobesioides* Fosl.
A. Part of a vertical section of the type specimen;
B. Similar section of the specimen fig. 30 *C*; × 72.

Occurrence: The species is commonly distributed over the greater part of the investigated area, but is on the whole scarce. It seems to occur not only in shallow water, as is probably the case with most of the other species of this genus, but it descends to a rather great depth. In most cases, however, it has only been found overgrown particularly by other calcareous algae. Cp. the list of stations with the particulars added.

Area: Indic: The Maldives and Laccadives [1]), the Red Sea [1]).

I have above under *Lithothamnion fragilissimum* mentioned some calcareous algae occurring in fossil sediments from New Guinea, among them also *Mastophora melobesioides*.

It has generally been assumed that recent Lithothamnia also are represented in fossil sediments, i. e. the genera *Lithothamnion* and *Lithophyllum* at least. But a comparison between fossil and recent species has seldom been made, particularly because of the unsufficient knowledge of these algae. An exception forms however *Lithophyllum racemus*, a species which

1) At the Laccadives it has been found overgrown by *Goniolithon laccadivicum*, and at El Tor in the Red Sea overgrown by *Goniolithon Foslici*.

rather long ago has been considered to occur both fossil and recent. Thus SOLMS-LAUBACH remarks in Corall. Monogr. p. 18: "Dass sich *Lithothamnion Racemus* und ebenso das nachher zu besprechende *L. ramulosum* [1]) seit der Tertiärzeit in unveränderter Weise fortgepflanzt hat, ist mir unzweifelhaft. In den pliocänen Kalken von Syrakus (Latomia dei Cappucini) und von Girgenti (rupe Atenea) finden sich Bänke, die ausschliesslich aus Nulliporen gebildet sind. Ich habe an Ort und Stelle zahlreiche Individuen gesammelt, die sofort als zu den beiden erwähnten Arten gehörig angesprochen wurden und die auch, zu Hause genauer untersucht, auf Dünnschliffen vollkommen den gleichen Bau wie die recenten, überall an Siciliens Küsten vom Meere ausgeworfenen Pflanzen erkennen liessen". Also ROTHPLETZ in Foss. Kalkalg. p. 320 mentions this species living as well as fossil. As regards the connection mentioned, GÜMBEL [2]) aptly remarks: "Sie reichen hier (in den Pliocängebilden des Monte Mario), indem sie in den diluvialen Muschelbänken unzweifelhaft sich fortsetzen, den Gebilden der Jetztzeit die Hand, welche von den Wellen losgelöst und an den Strand gespült sich mit Muschelschalen und sonstigem Meeresauswurfe stellenweis zu festem Gestein vereinigen". The species described by him l. c. p. 39 under the name of *Lithothamnion pliocaenum* from Monte Mario most probably also represents a fossil form of *Lithophyllum racemus* [3]). In addition, the arctic *Lithothamnion glaciale* is known from several post-glacial sediments both in Norway and Greenland. There are also other species recent and fossil which, when compared more closely, will not unlikely prove to be identic, although it is often impossible to make sure of the relation. Thus in several recent species the reproductive organs are more or less superficial and get dissolved after maturity, not leaving conceptacles which become overgrown by new-formed tissue, and, therefore, it can be impossible to decide even to which genus the specimens belong when they are sterile. This is particularly the case in several species within e. g. the genus *Lithothamnion*, whereas in e. g. the genus *Lithophyllum* the conceptacles mostly become overgrown, and in the genus *Archaeolithothamnion* the cavities after the sporangia as well. A similar fact makes its appearance in fossil species too. Therefore, such ones in many cases cannot be determined with any degree of certainty, when they are destitute of overgrown conceptacles. Besides, of fossil species frequently but fragments are in hand, and the structure often affords but an uncertain character. On the other hand, specimens with well developed overgrown conceptacles seem mostly to be recognizable even in fossil sediments, but by no means always.

The mentioned sections, which Professor K. MARTIN kindly sent me for examination at the request of Madame A. WEBER-VAN BOSSE, are from the island Soëk in Geelvink Bay on the northern coast of New Guinea. Those "121. v. Rosenberg (6) Soëk" contain, among other calcareous algae, several smaller or larger fragments of a plant which in my opinion without any doubt must be ranged with *Mastophora melobesioides*. Professor A. WICHMANN of Utrecht also kindly sent me a number of sections for examination. Among these one is from Mineralogisch-

1) This species likely includes more than one species, as suggested by SOLMS-LAUBACH himself, at least *Lithothamnion calcareum* f. *squarrulosa* and *Goniolithon Brassica-florida*.

2) C. W. GÜMBEL. Die sogenannten Nulliporen und ihre Betheiligung an der Zusammensetzung der Kalkgesteine, I. — Abhandl. d. Bayer. Akad. d. Wissensch. Mathem.-phys. Cl. vol. XI, 1874, p. 29.

3) As to the measurements of the cells of the species described by GÜMBEL l. c. cp. ROTHPLETZ. l. c. p. 303.

Geologisches Institut in Utrecht, — "G. 13. 1897. N° 3542. Kalkstein-Hügel hinter Skroë, Neu-Guinea"; another "Neu-Guinea Exped. 1903. N° 734. Lithothamnion Kalkstein. Kap Haharu bei der Tami-Mündung, Neu-Guinea"; and some ones "166. Macklot. Pulu Samauw". (Cp. p. 16). These sections too show some fragments of the same species, which apparently is rather commonly dispersed in fossil sediments in the said regions. However, in the sections from Pulu Samauw the species in question is very scantily represented in company with numerous fragments particularly of a species, which probably is identic with *Lithothamnion erubescens*, although the latter not ascertainable with certainty. Fig. 32 represents a part of the plant in one of the sections from Soëk. It coincides in every respect with similar sections of recent specimens. Cp. fig. 31. Among the rather numerous fragments examined I have not seen any one differing. Besides, in one of them occurs even a part of a conceptacle, which also in the main agrees with those of sporangia in the species in question. Thus another species is added to those already known living as well as fossil.

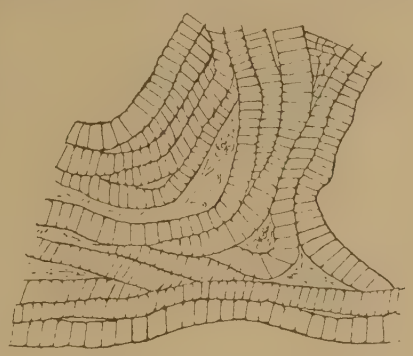

Fig. 32. *Mastophora melobesioides* Fosl. Part of a vertical section of fossil sediment from Skroë; × 72.

II.

CORALLINEAE VERAE OF THE MALAY ARCHIPELAGO

BY

A. WEBER—VAN BOSSE.

With plate XIV—XVI.

Introduction.

In ARESCHOUG's Corallineae in J. G. AGARDH's Species, Genera et Ordines Algarum, the *Corallineae verae* are divided into five different genera: *Amphiroa*, *Arthrocardia*, *Cheilosporum*, *Jania* and *Corallina*. The distinction between these genera is based upon the position which the conceptacles, keramidia Aresch., occupy on the plant. The validity of these five genera has often been disputed; *Jania* and *Corallina* have so many characters in common that SOLMS-LAUBACH united *Jania* to *Corallina* in his excellent monograph "Die in Neapel's Umgebung bis jetzt beobachteten Corallineenformen", and SCHMITZ and HAUPTFLEISCH in ENGLER und PRANTL's "Pflanzenfamilien" I Theil, have sunk *Arthrocardia* into *Cheilosporum*. The characters hitherto employed to distinguish the genera are indeed very confusing, for they are very variable, and again the characters distinguishing the species are not better defined than those of the genera. It was therefore with much doubt as to the success of my work that I undertook to name the *Corallineae* of the Siboga Expedition.

This collection contained a great number of specimens belonging to different species of *Amphiroa*; *Arthrocardia* failed to be represented; of *Cheilosporum* there were two species, of *Jania* two and of *Corallina* one. *Amphiroa* as forming the greatest bulk of the collection was studied first; and this study afforded me material for modifying the whole group of the *Corallineae verae*. The following pages however treat principally of the genus *Amphiroa*.

While naming the *Amphiroae* of the Siboga Expedition I was struck by the fact that two or three species, of which I had much material at my disposal, showed such differences in their outward appearance, that, seen apart, the different branches of one plant would have to be ranged under different species if I were to use the outward form of the joints or the position

occupied by the conceptacles as a guide, whereby to name my specimens. On the other hand I found that specimens which looked much alike, belonged to quite different species.

I tried to find an anatomical character, that would prove a surer guide for the determination of the species of this genus and that would be less liable to variation than the form of the separate joints, the manner of ramification, the diameter of the conceptacles or the number and manner in which they appear on the joints; characters which certainly have a great value and have been used till now, but which are not implicitly to be relied upon in all species.

LAMOUROUX [1]), ARESCHOUG [2]) and YENDO [3]) when describing new species have made some very interesting remarks about the node between two joints, but nowhere did I find a systematic and careful study of the nodes. SOLMS-LAUBACH tells us only that the node of Corallina consists of one layer of long pericline cells, that of *Amphiroa* of two layers of pericline cells, while the layer of cortical cells falls off as a rule and is only to be found abnormally in some feeble specimens of *A. verrucosa*.

While pondering over this question I remembered the results obtained by Miss E. S. BARTON [4]) while investigating the nodes of *Halimeda*, and it occurred to me that perhaps the nodes of *Amphiroa* might also reveal an anatomical character, that would be a useful help in classifying the different species.

In order to understand the structure of the node of *Amphiroa* it is necessary to recall in a few words the structure of these plants, giving first a little historical survey of all we know about the genus *Amphiroa*.

Historical.

The genus *Amphiroa* was created by LAMOUROUX [5]) in 1812 with the following diagnosis: "Plants with filamentous, articulated tufts, branching; branches dichotomous or verticillate, joints entirely separated by a horny substance, naked". After this short diagnosis LAMOUROUX cites *Corallina tribulus* Ell. and *C. cuspidata* Ell. as examples of the new genus adding the following words: "and many non-edited species". I wish to call attention to the fact that LAMOUROUX in his first note on the genus *Amphiroa* mentioned *Amphiroa (Corallina) tribulus* Ell. and *Amphiroa (Corallina) cuspidata* Ell.; they are therefore the types of the genus. In his "Histoire des polypiers coralligènes flexibles 1816" he places *Amphiroa* between *Cymopolia* and *Halimeda*. *Corallina* is described before *Cymopolia*. This shows the value LAMOUROUX attributed to the articulated appearance of all the above named genera, two of which belong to the *Florideae* and two to the *Chlorophyceae*.

ENDLICHER [6]) 1836—47 divided the genus in different sections which were taken up and worked out by DECAISNE.

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1) LAMOUROUX. Histoire des Polypiers coralligènes flexibles. Caen 1816.

2) J. E. ARESCHOUG in AGARDH's Genera et Species Floridearum 1851, p. 506.

3) YENDO. Corallinae verae Japonicae. Journ. of the Coll. of Science. Imp. Univ. Tokyo. vol. XVI, prt. 2, 1902. — Corallinae verae of Port Renfrew. Minnesota Botanical Studies 1902.

4) E. S. BARTON. The Genus *Halimeda*. Monogr. LX. of "Uitkomsten op zool., bot., ocean. en geol. gebied der Siboga-Expeditie".

5) LAMOUROUX. Essai sur les genres de la fam. des *Thalassiophytes* non articulées. Mem. du Muséum. Paris 1812.

6) ENDLICHER. Genera plantarum cum supplementis. Vindobonae 1836—1847.

DECAISNE [1]), 1842, based his division of the family of the *Corallinaceae* on the form and position of the conceptacles and distinguished the genera: *Corallina*, *Jania*, *Amphiroa* and *Melobesia*. Under the name of *Amphiroa* he united all the species which bear on their joints wartlike or conical conceptacles, and he divided the genus into four sections according to the joints: (1) cylindrical with wartlike conceptacula, *Euamphiroa*; (2) flattened, obcordate, subalate, with conical conceptacula, *Arthrocardia*; (3) flat and two-edged with conical conceptacula, *Eurytion*; (4) obcordate with acute lobes bearing conceptacles on their superior margin, *Cheilosporum*. But he adds that this difference alone is not sufficient as a generic character, for one observes transitions between the cylindrical branches of the typical *Amphiroa* and the flattened branches of the *Arthrocardia* section, just as one sees the conceptacles developing gradually on the side of the joints and thus forming the section named *Cheilosporum*.

Two years later ZANARDINI [2]) 1844 treated of the *Corallines* and he was the first to call attention to the anatomical differences between *Amphiroa* and *Corallina*. He pointed out that in the genera *Jania* and *Corallina* the cells — which he still called articoli and otricoli — have all the same dimensions, but that this is not the case with *Amphiroa*, where short cells are intercalated at regular intervals between long ones. This disposition of the cells seems, according to ZANARDINI, to belong exclusively to the genus *Amphiroa* and by this internal structure it is distinguished at once from either *Jania* or *Corallina*. By these alternating layers of long and short cells the transverse zones of *Amphiroa* are indeed much more marked than in all other genera; but this remark of ZANARDINI seems to have been overlooked by succeeding authors.

HARVEY [3]) (1847—1849) and KÜTZING [4]) (1849) followed DECAISNE and characterized the genera by the form of the fruit. ARESCHOUG (1851) used both the form of the joint and that of the fruit but as GRAY [5]) (1867) observed: "Both these characters are good, for they afford the means of dividing the species into very natural groups but in most of these groups there are always species, which combine the characters in such a manner as to make it difficult to determine to which genus they are most nearly allied". GRAY created in 1867 the genus *Lithothrix* which was sunk into *Amphiroa* by ANDERSON [6]) in 1891.

SOLMS-LAUBACH in his above-quoted monograph of the *Corallines* of the Gulf of Naples (1881) treated of the genera *Amphiroa*, *Melobesia*, *Lithothamnion*, *Lithophyllum* and *Corallina*. He pointed out the development of the fruit of *Corallina*, which had already been the object of such arduous research by THURET and BORNET [7]) in 1878, and he also called attention to the many points of resemblance between *Amphiroa* and *Lithothamnion*, which will be spoken of, when the anatomy of *Amphiroa* is discussed.

In "Die Natürlichen Pflanzenfamilien" of ENGLER (1897), the *Corallinaceae* are treated

1) DECAISNE. Essai sur une Classification des Algues et des polypiers calcifères. Ann. des Sc. Nat. 2me ser., t. XVII, Paris 1842.

2) ZANARDINI. Revista sulle *Corallinee*. Atti R. Istituto Veneto vol. III. Serie I. Venezia 1844.

3) HARVEY. Nereis australis or algae of the Southern Ocean. London 1847—1849. Phycologia britannica. London 1849—1851. Nereis borealis americana. London 1846—1851.

4) KÜTZING. Phycologica generalis. Leipzig 1843. Tabulae phycologicae 1849—1869. Species algarum 1849.

5) J. E. GRAY. *Lithothrix* a new genus of Corallinae. Journ. of Botany. V, 33, Febr. 1867.

6) ANDERSON. Zoe vol. II, 1891, p. 225.

7) THURET et BORNET. Études phycologiques. Paris 1878.

by F. SCHMITZ and P. HAUPTFLEISCH. The authors recognize only the genera *Amphiroa*, *Cheilosporum* and *Corallina* out of the old *Corallineae verae* of ARESCHOUG. When speaking of *Amphiroa* they call attention to the joints as being "quergezont mit dickem Bündel dicht zusammengeschlossener, in bestimmt alternierender Weise gegliederten Markfasern". This seems to point to the long and short cells described by ZANARDINI.

SETCHELL and GARDNER [1]) in their valuable paper on the Algae of Northwestern America (1903) say: "After a long study of the forms of *Amphiroa* with flattened joints from the western coast of North-America, we have come to the conclusion that they are all forms of one polymorphous species, the forms owing their very considerable differences to variations in the environmental conditions under which they may be found growing .... We do not understand the reasons for referring some of the forms to the genus *Cheilosporum*, as YENDO has done, since that genus if separable at all from *Amphiroa*, applies only to a very limited number of species, none of which occur in our territory".

In my opinion SETCHELL and GARDNER are perfectly right in considering the algae known as *Amphiroa tuberculosa*, *A. Orbigniana*, *A. Californica* as forms of only one polymorphous species, but I think that this species belongs to the genus *Arthrocardia* and not to *Amphiroa*. The reasons why I think so will be shown in the following pages.

Anatomical.

The fronds of *Amphiroa* consist of a tuft of vertical, sometimes horizontally spread, calcified branches which, according to SOLMS-LAUBACH, probably arise from a horizontal disc, or at all events from a small 'Keimscheibe', resulting from the first divisions of the germinating spore. The branches are as a rule articulated and each joint (articulus) is separated from the next one by a narrower or broader articulation or node (geniculum of YENDO) of non calcified cells.

The branches, whether ascending vertically or spreading horizontally, have all a central strand of elongated cells and a cortical layer of isodiametrical or ellipsoidal cells. The cells of the central strand have their origin in a layer of meristematic cells at the flat top of the branches, where, in conformity to the mode of growth described by KNY [2]) for *Jania rubens*, *Corallina officinalis* and *C. granifera*, they divide as a rule only with transverse walls except at the periphery, where the cells are divided alternately by transverse and by oblique longitudinal walls, these latter ones running from the inner part of the lower transverse wall to the apical part of the outer longitudinal wall. The cells resulting from this latter division are pushed sideways towards the periphery where, by subsequent division, they become smaller and smaller, are divided by transverse and longitudinal walls and form the cortex. This mode of growth proper to *Jania* and *Corallina*, is also that of *Amphiroa* as SOLMS-LAUBACH has pointed out, but he showed at the same time that a continuous layer of "Deckzellen" covers the meristematic cells of *Amphiroa* even at the moment of the most intense growth. This layer of Deckzellen, which is also to be found in *Lithothamnion* is only now and again renewed

1) SETCHELL and GARDNER. Algae of northwestern America. Berkeley 1903.
2) KNY. Bot. Zeitung 1872, p. 705.

from below and the old layer thrown off. SOLMS-LAUBACH speaks also in his paper of the growth in thickness of the cortical layer after the manner of *Lithothamnion*, whereby new conceptacles can spring forth and old ones becoming overgrown, are submersed in the tissue of the plant. SOLMS-LAUBACH refers rather briefly to the nodes, only saying that the node consists of two layers of cells and that the cortical layer falls off as a rule.

The anatomical structure, first noted by ZANARDINI and afterwards mentioned by SCHMITZ and HAUPTFLEISCH proved to be a character of great systematic value and I will therefore describe it at full length.

In *Arthrocardia*, *Cheilosporum*, *Jania* and *Corallina* the cells in the central strand of each joint have the same dimension throughout the whole joint; each successive layer is as a rule as long and as broad as the preceding or succeeding one. The cells stand in vertical rows one above another; they may grow a little longer or shorter, the difference is a gradual one, never an abrupt one.

In *Amphiroa* the case is different; 1, 2, 3, 4 or even more layers of long cells (articoli Zan.) will alternate with a row of short cells (otricoli Zan.) marking a period of intra-nodal growth; each joint may have several of these periods of growth. The long cells in the successive rows of one period of growth are not of exactly the same size; as a rule the cells of the first row are the longest, the cells of the succeeding ones becoming gradually a little shorter, but the transition to the last row, the one with the short cells, is as a rule abrupt. The regularity with which these rows of long and short cells alternate is liable to much variation in each species and in each plant. Still a certain rule may be detected. Thus in the case of *Amphiroa fragilissima* (L.) Lam., one of the many types of the genus, 4, 5 or 6 rows of long cells will be followed by a row of short ones. This number of long-celled rows may be reduced to 2 or 3, or increase to 7 or 8, but by far the greater number of joints will have intra-nodal periods of growth consisting of 4, 5 or 6 rows of long cells. In *Amphiroa verrucosa* Kütz. we find very regularly one row of long cells alternating with one row of short cells and in *Amphiroa rigida* Lam. two long ones alternating with a short one, but in the latter case the alternation is not so regular as in *A. verrucosa*.

Studying the nodes of other *Amphiroae* I found that the nodes of these plants do not always consist of two rows of pericline cells, as is the case with the *Amphiroae* of the Gulf of Naples described by SOLMS-LAUBACH but that a great number of rows may take part in their formation (Pl. XV, fig. 5); the cortical layer of the node does not drop off but persists in many species and even grows in thickness, and in one or two species the cortical layer remains calcified and the node is only indicated by a zone of uncalcified rows in the central strand (Pl. XV, fig. 6). Almost startling is the wealth nature exhibits in producing such a simple thing as a node of *Amphiroa*. But however different the ways of forming the node may be, one thing is invariable and can be relied upon as a fixed rule: the cells in the node have always the same dimension or nearly so as the cells in the whole plant. The only exceptions which I have discovered to this rule are *A. rigida* and *A. verrucosa*, the long cells of which have an inclination to grow longer still in the node; but even here the differences are not great.

When one studies a young growing branch of *Amphiroa* in a decalcified state and in longitudinal sections, the nodes are indicated by the different colour of the membrane. That is all. The whole young top presents the same disposition of cells throughout its whole length and the rows of long and short cells succeed one another quite regularly.

On the other hand if one studies longitudinal sections of either *Arthrocardia*, *Cheilosporum*, *Jania*, *Corallina*, *Lithothrix* or of our new genera *Metagoniolithon* and *Litharthron*, the disposition of the cells at the top of the young branch is quite different in the region of the future node, corresponding with the structure of the adult node in each of these latter genera.

It appeared to me that this difference in anatomical structure was indeed a good character whereby to distinguish the genus *Amphiroa*. It seemed to me to be of great value since the study of the development of the cystocarp offers many difficulties, arising from the smallness of the object; and even if one succeeded in tracing its development, it is highly probable that it would follow the same mode as SOLMS-LAUBACH has described for the *Corallinae* and thus not afford a good character whereby to distinguish *Amphiroa* either from *Arthrocardia* or *Cheilosporum*. How difficult such research would be is shown clearly by the very few conceptacula with procarpia I met with during my whole investigation. In my preparations I saw mostly conceptacula with ripe or unripe tetraspores; next came antheridia and conceptacula full of ripe carpospores. Rarely have I seen a conceptaculum with procarpia or cystocarp-spores in course of development.

Since however the anatomical structure of the frond first recognized by ZANARDINI and of the node proved indeed a good generic character whereby to distinguish the genus *Amphiroa*, I have had to strike out of that genus a great many species that had been described — often not by their authors, but by succeeding ones — as belonging to this genus. The algae which LAMOUROUX first mentioned as belonging to *Amphiroa*, have the same structure as mentioned by ZANARDINI. They constitute the types of the genus; and other species, differing from these types even though they were also called *Amphiroa* by LAMOUROUX in his later work of 1816, must be taken out of the genus.

The genus *Amphiroa* when cleared of all species that are only like it in outward appearance is a very well limited group. The presence of nodes distinguishes it from *Lithothamnioneae*; the continuity of the frond — the same anatomical structure of the central strand throughout the whole frond —, distinguishes it from *Arthrocardia*, *Cheilosporum* or *Corallina*, where long cells are intercalated between two succeeding joints. SOLMS-LAUBACH has already called attention to the fact, that *Amphiroa* has very many affinities with *Lithothamnion*; and the results I obtained during my investigations tend only to show the near relationship of *Amphiroa* to *Lithothamnion*. The anatomical structure of *Amphiroa*, as it shows itself in distinct periods of growth, is a character which we find also in *Lithothamnion*, and it is interesting to observe how the node is gradually developed in species of *Amphiroa* with broad, often irregularly branched fronds as *A. crassa* or *A. tribulus*, the fronds of which resemble outwardly small forms of *Lithothamnion*. We see in these two species, as will be shown more fully in the following pages, that the cells of the central strand alone contain no chalk and form a node often entirely surrounded by a layer of calcified cells. A further stage in the development of the node is

marked by *Amphiroa ephedraea* where the node consists of the whole central strand and the whole cortical layer, and intervening forms between these two extremes are numerous.

To the genus *Amphiroa* belong those plants which have fronds built up of a central strand of filaments having alternating rows of long and short cells communicating with one another by primary and secondary small pores. How these rows of cells alternate is a question of less importance and this will be considered when treating of the different species. The *Amphiroae* have conceptacula as wartlike protuberances on cylindrical joints (*Euamphiroa* Dec. pro parte) or as conical processes on flat two-edged joints (*Eurytion* Dec.) or half immersed in the tissue of the frond: *A. crassa*, *A. tribulus*. Their nodes consist always of the central strand; the cortical layer may split off and leave the node naked, or persist and take part in the formation of the node. The rows of cells of the central strand have with rare exceptions the same size in the node as in the joint. All *Amphiroae* have a layer of "Deckzellen" covering their growing tops.

I propose the name of *Metagoniolithon* for those algae which have joints consisting of rows of cells all of the same dimension and communicating in their longitudinal walls by relatively big thin places in these walls. The whole central strand and cortical layer take part in the formation of the node, the cells of which are much smaller than in the joint. The ramification takes place at the node and from the non-calcified tissue of the node spring forth successively new branches, which are therefore no true whorls, though they surround the node like a whorl. On sectioning the young top of *Metagoniolithon graniferum* (*Amphiroa granifera* Harv.) I saw that it was covered by a thick mucilaginous layer in which slight striae were visible, reminding me of the Membranprismen, described by SOLMS-LAUBACH for *Corallina mediterranea*. I saw no layer of "Deckzellen".

Their conceptacles have the form of conical processes. These are first seen on the inner side of secondary branches, but in old fronds they are scattered along the whole branch.

To *Metagoniolithon* belong the following three species, known as species of *Amphiroa*:

Metagoniolithon charoides Lamx.
Metagoniolithon graniferum Harv.
Metagoniolithon stelligerum Lamk.

Lithothrix aspergillus Gray (*Amphiroa aspergillus* Anders.) is such an aberrant alga, that it could not be kept amongst the *Amphiroae*, by anyone who decalcifies and sections its joints. It will be spoken of in the succeeding pages, as will also *Amphiroa australis* Sond., which proved to be so totally different that it had to be taken out of the genus *Amphiroa*. I propose for it the name of *Litharthron*; the diagnosis of this genus will be found in the following pages. Neither *Metagoniolithon* nor *Lithothrix* nor *Litharthron* were to be found amongst the collection of the Siboga; I looked at these different algae for comparison with the Siboga-material, and thus found out, that they were generically different from *Amphiroa* and also from one another.

The genera *Arthrocardia*, *Cheilosporum*, *Jania* and *Corallina* are closely allied. In all four the central strand of filaments is built up of cells of equal dimension throughout the whole joint. In *Arthrocardia* and *Cheilosporum* the cells communicate, both by their primary pores,

and by thin places in the longitudinal walls, after the manner of the cells of *Metagoniolithon*, but the thin places are smaller than in this latter genus. In *Jania* and *Corallina* it appeared to me that the cells adhered only at their primary pores and that secundary ones were scarce or very obsolete, for the cells seemed always to be quite free from one another in transverse direction. The nodes in all four genera consist of one row of long pericline cells, surpassing many times (even so much as 12 times) the length of the cells of the central strand. I saw no layer of "Deckzellen" at the top of the branches.

The conceptacula grow on the cylindrical or winglike broadened joints in *Arthrocardia* and at the top of the joint, immersed in its tissue in *Cheilosporum*, but I have seen many specimens to which the words of GRAY could be applied, that it was difficult to say to which group they belonged. Many algae considered till now to belong to the genus *Amphiroa* must be placed in the genus *Arthrocardia*:

Amphiroa tuberculosa (P. & R.) Setch. & Gardn.
Amphiroa cretacea (P. & R.) Aresch.
Amphiroa variabilis Harv.
Amphiroa Darwini Harv.
Amphiroa rudis Harv.
Amphiroa epiphlegnoides Ag.
Amphiroa vertebralis (Harv.) Aresch.
Amphiroa declinata Yendo.
Amphiroa aberrans Yendo.

and perhaps others, that I have not seen. *Amphiroa Wardii* Harv. and *A. Stangeri* Harv. were already taken out of the genus *Amphiroa* by ARESCHOUG.

Corallina and *Jania* are easily known from the preceding genera because they bear their conceptacula immersed at the top of the branches. In *Corallina* the cells of the central strand are relatively short for such sturdy plants and have the same size throughout the joint. In *Corallina officinalis*, *C. mediterranea* and *C. Cuvieri* the cells of the nodes are many times longer than the cells of the central strand in the joint.

In *Jania adhaerens* and *J. rubens* the cells of the central strand in the joint are relatively long for such slender plants and the cells in the node are not longer, sometimes shorter, as a rule of the same size. This is beautifully illustrated by KÜTZING Phycologia generalis pl. 79, fig. I and II. Fig. I shows a node of *C. officinalis* and part of the two neighbouring joints, and we see that the cells of the node are much longer than the cells of the joint; in fig. II we see a short-celled node of *Jania rubens* and the long cells of the joints still partially covered by cells of the cortical layer.

In *Jania longifurca* the cells of the node are twice as long as those of the central strand in the joint. *Jania longifurca* is a transition from the *Corallinae* with long-celled nodes to such *Janiae* as have short-celled nodes.

This difference in length of cells of the node, being as far as I know, the only difference between *Jania* and *Corallina*, is not a very striking character; still it may be a help in disentangling the confusing group of *Corallinae*, and the name of *Jania* may perhaps be retained

for those slender forms, which have a central strand with cells of almost equal size in the joints and in the nodes.

Synoptical Key

to the Genera of the *Corallineae verae.*

I. Fronds branched, articulated, calcified joints separated by horny pliable nodes. Joints consisting of a central strand of filaments and of a more or less developed cortical layer. Conceptacula either occurring as wartlike or conical processes on the joint or immersed in the tissue of the joint.

a. Joints cylindrical or broadened; in the central strand rows of short cells are intercalated between rows of long cells all standing vertically one above another. Nodes consist of two or more, — rarely of one, — rows of cells that alternate in the same way as, and have the same size or almost the same size as, the cells in the joint. Conceptacula on the joints . . . . . *Amphiroa* Lamx.

b. Joints cylindrical; in the central strand the cells have throughout the whole joint almost the same dimension and stand vertically one above another. Nodes consist of many rows of cells which are much smaller and have thicker walls than the cells in the joint. Conceptacula on the joints. . . . . *Metagoniolithon* n. g.

c. Joints flat short elliptical in outline, with a thin central strand of non-calcified, intricated filaments, with cells not standing vertically one above another, and with a considerable layer of calcified cortical cells. Cells of cortical layer large, near central strand full of big grains of starch, growing smaller towards the periphery, covered by a thick cuticule. Nodes consist of small, thick-walled cells. Conceptacula unknown. *Litharthron* n. g.

d. In the central strand all cells have almost the same dimension throughout the whole joint. Nodes consist of one row of long cells.

1. Joints cylindrical or broadened winglike; conceptacles form conical protuberances on the joint . . . . . *Arthrocardia* Aresch.
2. Joints cylindrical or broadened winglike; conceptacles on the upper margin of the broadened wing, immersed in the tissue of the joint . . *Cheilosporum* Aresch.
3. Joints cylindrical or flattened; conceptacles at the growing top of the branches, immersed in the tissue of the joint . . . *Corallina* Lamx. incl. *Jania* Lamx.

II. Fronds branched, articulated, cylindrical, calcified joints separated by calcified constrictions of the frond. The joints consist of a central strand of long, undivided non-calcified filaments standing in vertical rows with the calcified cells of the constrictions, and of a cortical layer of calcified horizontally elongated cells. Conceptacula on the joints . . . *Lithothrix* Gray.

Amphiroa Lamx.

LAMOUROUX, Mémoire du Musée t. II, Paris 1812, Polyp. flexibles 1816.

The characters of the genera having been established I began the naming of the *Amphiroae* of the Siboga collection and tried to find a character, that would help me to distinguish the

often very confusing species. Whether the anatomical structure of a plant, — the number for instance of long-celled rows in a period of intra-nodal growth, the height of the cells, and the dropping off or persisting of the cortical layer in the node, — offered characters of specific value, was a question that had to be solved. The result was at first not very satisfactory, variations in the successive number of long-celled rows in a period of intra-nodal growth occur so often, even in the same plant, that one must be cautious not to jump to rash conclusions, and other characters already described at length by previous authors, for instance the size of the conceptacles, the form of the frond etc. must be taken in consideration before naming a species. Still if the same constant structure is found regularly in different plants, this structure may be a good help to recognize a species, for it is highly probable that such plants will belong to the same species even when the outward form happens to be different. The node of *Amphiroa* offered a character of importance and I will therefore describe it at full length.

I began my studies on *Amphiroa* with specimens preserved in alcohol of *A. rigida* and *A. cryptarthrodia*; these plants were authentic specimens of SOLMS-LAUBACH, kindly given to me by Prof. MAYER at Naples. My methods of research were very simple; the nodes, which soon became a point of special interest to me, did not allow the use of ground sections; these were only used now and than for comparison; I decalcified my plants trying various liquids, but for anatomical research Perenyi's fluid gave very good results and I used it continually. The uncalcified material was stained, hardened, and often imbedded in celloidin. Other pieces were sectioned immediately as soon as they were hard enough; the one thing I had to be very careful of, was that my sections should go straight through the middle of the plant. If they did not do this, I was not sure that the short cells of the branches, forming the cortical layer, did not interfere with the succession of short and long cells such as really occur in the middle of the plant.

A. rigida and *A. cryptarthrodia* both have nodes consisting, as SOLMS-LAUBACH has already observed, of two rows of cells. The node of *A. rigida* has been beautifully figured by YENDO; it consists of two cells which have the same size, and the ends of which in the node rest not horizontally one above the other but obliquely.

I thought this might tend to increase the power of resistance in the slender node.

The node of *A. cryptarthrodia* consists also of two rows of cells, but here the lower one is much larger than the upper one. In the joint the large cells have much more chalk in their lower part than in the middle where it seemed to me that they were less calcified than the cells of *A. rigida*. This has been indicated in the fig. 14, on Pl. XVI, which was drawn at the beginning of my research. In *A. cryptarthrodia* I observed also that the cortical layer persisted much more regularly than I had supposed it would do according to SOLMS-LAUBACH. These two algae had nodes so different from one another that a look at a section taken through the node was sufficient to show to which species the specimen, from which the section was taken, belonged. This encouraged me to pursue my research on the node and I submitted the whole Siboga material to an investigation on those lines.

Amongst the collections of the Siboga were two species of which I had much material at my disposal and naturally I began my research with these. My first impression had been

that at least one of these species was new to science but, owing to the kindness of Prof. LIGNIER at Caen, I was allowed to study the type specimens of LAMOUROUX; and this study convinced me that my specimens belonged to species already described by LAMOUROUX as *A. foliacea* and *A. crassa*. This latter is an almost forgotten species described by LAMOUROUX at the end of the zoological part of "Le voyage de l'Uranie par FREYCINET".

My sections of *A. foliacea* showed that the cortical layer participated as a rule in the formation of the node; it grew in thickness with the thickness of the frond, it was an integral part of the node; the joint was often broader, but otherwise the only difference between node and joint consisted in the former not being calcified.

In *A. crassa* the central strand alone forms the node; its cells alone are non-calcified and have thick membranes but the cortical layer persists; it has thin-walled calcified cells and forms an integral part of the joint. In a small form of *A. crassa* the node was outwardly not visible, and while sectioning this plant it often happened that the node fell out of the section; in dried plants the contact between node and cortical layer is very loose, because a layer of cells that surrounds the node, tears very easily, the upper and under joint remaining connected by the calcified cortical layer. In larger specimens with long joints the cortical layer splits however horizontally leaving the node visible for a very short space.

The specimens in LAMOUROUX's herbarium were rather flat, broad and palmate; I had exactly the same specimens but also long, branched, spreading specimens, described by GRUNOW as *A. Godeffroyi* and small compact ones, and all had their nodes built up after the same type.

Ought I now to consider these specimens as different species or were they only different forms of one species? To this question it appeared to me that my specimens of *A. foliacea* gave an answer.

Of this latter species I had specimens exactly like those in the herbarium of LAMOUROUX, others again that were much narrower and finally creeping ones with much broader winged joints. I suppose that these are identical with the *Amphiroa* described by GRUNOW from Ovalau in his paper on the "Algen der Fidschi, Tonga und Samoa Inseln". Some of the branches of these latter fronds instead of spreading horizontally grew in a vertical direction and when growing erect the form of the branch changed. It grew narrow, almost cylindrical with a small wing and differed totally from the creeping joints from which it sprang and also from the type of LAMOUROUX (Pl. XIV, fig. 1—8); they resembled and were in fact identical with the alga named *A. nobilis* by HAUCK in his paper "Ueber einige von HILDENBRANDT im Rothen und Indischen Ocean gesammelte Algen. V". In all these branches the nodes were the same. This led me to conclude that since:

1° I had been fortunate enough to collect specimens that showed in an undeniable way the specific identity of branches so different, that seen apart, one would think they ought to be taken for different species, although they had the same anatomical structure of joint and node,

2° I could show that different species showed great difference in the anatomical structure of joint and node,

It was highly probable that species showing the same anatomical structure of joint and node belonged to one species.

If this conclusion is true a great number of species have to be sunk and can only be, according to smaller or greater deviations, retained as varieties or forms.

Working out the *Amphiroae* of the Siboga Expedition principally with reference to the structure of the node, I found that the collection contained the following species:

1. *A. fragilissima* f. *cuspidata* and f. *cyathifera*.
2. *A. anastomosans*, a new species nearly related to the former.
3. *A. foliacea* f. *typica* f. *nobilis*.
4. *A. anceps*.
5. *A. Bowerbankii*.
6. *A. ephedraea*.
7. *A. canaliculata*.
8. *A. crassa*, f. *Godeffroyi* and f. *minima*.

With the exception of *A. crassa* the cortical layer takes part in the formation of the node of all these species. The structure of the node is in all specimens the same in each species. In *A. anceps* the node shows a tendency to deviations, as did also the regularity wherewith long and short cells alternated in the central strand of the joint. This shows that *A. anceps* is a highly variable plant, whereas in *A. ephedraea* for instance the structure of the node and the regularity wherewith long and short cells alternate is much more constant. Since however the great variability of which the genus *Amphiroa* is capable, is amply shown by *A. foliacea*, I resolved to unite in one species all *Amphiroae* the nodes of which were essentially the same as the node of the type specimen of *A. anceps*.

Whether this conception of the species is right or wrong can only be made out by careful study on the spot where these algae grow; it may at least be a help for the present, and the study of the node will prevent various genera from being mistaken for one another, as was the case in some collections I have been able to study.

I will now proceed to a systematic description of each species contained in the Siboga collection.

1. *Amphiroa fragilissima* (Linn.) Lamx. Pl. XIV, fig. 5.

Corallina fragilissima Linné, Syst. nat. ed. 12, vol. I, p. 1305. Ellis et Solander. Zooph. p. 123, t. 21, fig. 9.
Corallina rigens Pallas, Elench. Zooph. p. 429 fide Areschoug.
Amphiroa fragilissima Lamouroux, Pol. flex. p. 298.
Amphiroa debilis Kützing, Spec. Alg. p. 700. Tab. Phyc. t. 8, pl. 39, 40.
Corallina cuspidata Ellis et Solander, Zooph. p. 124, t. 21, fig. 9*f*.
Amphiroa cuspidata Lamouroux, Pol. flex. p. 300.
Amphiroa cyathifera Lamouroux in Freycinet, Voy. de l'Uranie, Zool. par Quoy et Gaimard p. 627.
Amphiroa fragilissima Lamouroux, Areschoug in Agardh, Spec. Gen. et Ord. Alg. t. 2, 1851, p. 531.

f. *fragilissima*.

Amphiroa fragilissima Lamx.

Stat. 34. Labuan-Pandan.
Stat. 60 and 303. Haingsisi, Island Samau.
Stat. 71. Makassar.

Stat. 78. Lumu-Lumu shoal, Borneo-bank.
Stat. 93. Sulu Archipelago.
Stat. 172. Gisser.
Stat. 181. Ambon.
Stat. 193. Sula-Besi.
Stat. 307. Endeh, Ipih Bay.
Sikka, Flores. leg. A. Weber-v. Bosse 1888.

f. *cuspidata.*

Amphiroa cuspidata Lamx.

Stat. 60 and 303. Haingsisi, Island Samau.
Stat. 71. Makassar.
Stat. 81. Island Sebangkatan.
Stat. 89. Kanjungan Island.
Stat. 193. Sula-Besi.
Stat. 240. Banda.
Stat. 249. Roma Island.
Sikka and Maumeri, Flores. Padang, Sumatra. leg. A. Weber-v. Bosse 1888.

f. *cyathifera.*

Amphiroa cyathifera Lamx.

Stat. 71. Makassar.
Stat. 93. Sulu Archipelago.
Stat. 213. Saleyer Island.
Stat. 280. Kur Island.

Fronds articulated, cylindrical, branched at the node di- or trichotomously, often with adventitious branches. Joints long, many times longer than broad, in older specimens swollen at top and base in the form of a ball or pad, by local division in longitudinal and vertical direction of the cells of the cortical layer. Nodes swollen cushionlike in conformity with the swollen tops and bases of joints.

Central strand built up of 4—8 rows of long cells, seldom 2—3 rows of long cells, mostly 4 rows, followed by one or two rows of short cells.

Height of long cells from 60, 80, 100, 104, 120 μ, mostly 80 μ; height of short cells, 12, 16, 28 μ. These short cells mark the intra-nodal periods of growth, seen so distinctly through the cortical layer, and visible to the naked eye as little constrictions of the frond. In the middle of the central strand the cells are often a little compressed, towards the periphery they are a little broader. Cells of the central strand pass rather abruptly into the cortical layer, their rows therefore as a rule straight, horizontal, little curved.

In the node the structure of the central strand is the same as in the joint (Pl. XVI, fig. 2) the walls of the cells are only thicker not calcified; cells of the cortical layer very small, closely adhering together.

Conceptacles prominent not immersed in the frond, slightly elliptical seen from above, or round. Diameter of conceptaculum ± 300—340 μ.

The collection of the Siboga contains a great number of slender *Amphiroae* with long cylindrical joints and more or less thickened nodes. Comparing these with the authentic specimens

of LAMOUROUX, I came to the conclusion that my collection contained *A. fragilissima*, *A. cuspidata* and *A. cyathifera*, but that it was impossible to trace a sharp limit between these so-called species. Sectioning the node of an authentic specimen of LAMOUROUX of *A. fragilissima*, I was surprised to find that its structure was exactly identical with that of the node of *A. cyathifera*; this latter one being only much more sturdy. I do not attach great importance to this point, whether specimens are more or less slender, if they agree on all other points, for I have a specimen of *A. cyathifera*, with some fronds abnormally developed and bearing very thin slender branches, resembling exactly those of *A. fragilissima*. One long specimen from Banda looked quite like *A. fragilissima* at its top, like *A. cuspidata* in the middle, and some nodes at its base might be easily taken for nodes of *A. cyathifera*.

I therefore think, that it is right to give the name of *A. fragilissima* to all *Amphiroae* with cylindrical joints, swollen at their apical and basal part and with distinct periods of intranodal growth, clearly visible to the naked eye, even in dried specimens, as very slight constrictions of the frond, with swollen nodes, — not forgetting that the horny nodes shrink much in drying — and with prominent conceptacula.

The older names may be kept to designate the various aspects which this species can assume.

f. *fragilissima* syn. *A. fragilissima* Lamx. and *A. debilis* Kütz.
slender plants, joints thin, nodes not very conspicuous as a rule.

f. *cuspidata* syn. *A. cuspidata* Lamx.
plants stronger than the typical form, but not so strong as

f. *cyathifera* syn. *A. cyathifera* Lamx.
which is characterized by its strong swollen nodes.

I may perhaps be criticised for sinking the above named species into *A. fragilissima*, for it seems hard to believe that the delicate plant of LAMOUROUX should belong to the same species as the coarse *A. cyathifera*. But we must not forget, that we do not know how or when most *Amphiroae* were collected.

Slender forms will sometimes spring from old, thick, creeping branches, but whether therefore all slender fronds are young stages of plants that might become coarse and big if they had had time to live, I do not dare to assume. It appeared to me that many species had both a slender and a stouter form. The plants growing in deeper water showed, as a rule, a tendency to grow in length, while those growing in shallow water or exposed to the breaking of the waves, dwindled into small, compact, much branching forms. I believe that these different forms belong to only one species, but whether this difference in the form of growth is indeed the result of external influences is a question that for many algae must still be settled by careful investigation on the spot where these plants grow.

2. *A. anastomosans* n. sp. Pl. XIV, fig. 3, 4.

Tiny plants 1—1,4 cm. high, forming a compact tuft on the substratum. Fronds cylindrical, branching dichotomously, branches anastomosing frequently. Joints indistinct because

nodes are very inconspicuous; where nodes are visible they are composed of central strand and cortical layer. Intra-nodal period of growth consisting of 4, 5 rows of long cells, 36, 56, 72, 76 μ high, short cells $\pm$ 12 μ high.

Conceptacula prominent; diameter of conceptaculum 160—180 μ; tetraspores 48 μ high.

Stat. 78. Lumu-Lumu-shoal, Borneo-bank.
Sikka, Flores. leg. A. Weber-v. Bosse 1888.

The little plant is in all its details smaller than *A. fragilissima* and yet the structure of its central strand and its prominent conceptacula are so exactly like what one sees in *A. fragilissima*, that I feel convinced that the two plants must be closely allied. *A. anastomosans* is a dwarf-form, and its small conceptacula and the absence of pad-like swollen nodes have induced me to distinguish it as a new species.

3. *Amphiroa foliacea* Lamx. Pl. XIV, fig. 1—11.

Lamouroux in Voyage de l'Uranie par Freycinet Zoologie par Quoy et Gaimard, p. 628, tab. 93, fig. 2—31.
Areschoug in J. G. Agardh, Spec. Gen. et Ordines Algarum, 1851, p. 541.
Amphiroa squarrosa Grunow, in bot. herb. zu Hamburg!

f. *procumbens*.

Stat. 248. Island Tiur.
Stat. 282. Eastpoint Timor.

f. *erecta*.

Stat. 71. Makassar.
Stat. 78. Lumu-Lumu-shoal, Borneo bank.
Stat. 91. Muaras-reef, Borneo bank.
Stat. 93. Sulu Archipelago.
Stat. 99. North-Ubian. Sulu Archipelago.
Stat. 129. Island Karkaralong.
Stat. 240. Island Banda.
Stat. 261. Kei-Elat, Kei Islands.
Stat. 281. Timor.

Fronds branched, di- or trichotomously, with adventitious branches springing from the nodes, dimorphous: either creeping horizontally with broadly winged joints with undulating border, or ascending vertically with joints almost cylindrical, more or less flattened, more or less winged with narrow undulating border. Joints not swollen and pad-like as in *A. fragilissima*. Nodes consisting of central strand and cortical layer; as a rule as broad as the joint, but if the joint is very much winged, not quite so broad. Central strand built up of 3, 4 rows of long cells 44, 60, 76, 84, 92, 96 μ high, followed by a row of short cells 8, 16, 24 μ high. Cells of the central strand pass not abruptly at the periphery into the cells of the cortical layer forming the wing, sometimes in broad specimens these latter cells are quite as high as those of the central strand. Rows of cells of the central strand form curved lines, not straight ones as in *A. fragilissima*, conceptacula half immersed in the frond, not so prominent as in *A. fragilissima*. Diameter of conceptacula 240—400 μ; height of tetraspores 48 μ.

The different aspects which this *Amphiroa* can assume, have already been spoken of in the beginning of this paper. On account of its variability it is not an easily recognized plant. Its central strand and manner of forming the node have much resemblance to the central strand and node of young specimens of *A. fragilissima*, still both are easily recognized if carefully studied. *A. foliacea* has a strong tendency to flatten its frond and to form an undulating border, visible even in almost cylindrical joints. The joints are thick throughout their whole length and lack the pad-like swellings at top and base that characterize older joints of *A. fragilissima*. The half-immersed conceptacula, not nearly so prominent as in *A. fragilissima*, help further to distinguish this species.

A. foliacea is a widely spread plant; it can grow so sturdy as to resemble outwardly *Metagoniolithon charoides (Amphiroa charoides)* and I got it even under that name from the West Indies. A longitudinal section through both plants will however show at once how widely different they are.

The different aspects *A. foliacea* can assume may be characterized as follows:

f. *procumbens*. Pl. XIV, fig. 1.

fronds creeping, joints broad, winged with undulating border.

f. *erecta*. Pl. XIV, fig. 2—8.

fronds erect, joints slightly winged, sometimes almost cylindrical. This latter form is identical with the alga named *A. nobilis* Kütz. by HAUCK in: Über einige von HILDEBRANDT im Rothen Meere und Indischen Ocean gesammelten Algen.

GRUNOW again in his paper on the "Algen der Fidschi, Tonga und Samoa Inseln" speaks of an *Amphiroa* from Ovalau "bei welcher einige Aeste und Glieder sehr an *A. tribulus* andere aber durch die langgliederige, oft fast stielrunde dünne Gestalt sehr an *A. fragilis* erinnern". I think that this plant is *A. foliacea*, the more so because I found in the Herbarium of the Hamburg Museum *A. foliacea* under the name of *A. squarrosa* Grunow.

4. *Amphiroa anceps* (Lamk.) Decne. Pl. XVI, fig. 6—8.

Corallina anceps Lamarck, Mém. du Mus. II, 1810.
Corallina dilatata Lamouroux, Hist. des polyp. flexibles. Caen, 1816.
Amphiroa Karstalskii Postels et Ruprecht, Ill. Alg. Oc. Pacifici 1840, at Bot. Mus. in herb. Petersburg.
Amphiroa Cumingii Postels et Ruprecht, Ill. Alg. Oc. Pacifici 1840.
Amphiroa anceps Decaisne, Ann. des sciences nat. 1842. Bot., v. 2.
Amphiroa nobilis Kützing, Spec. Alg. 1849. Tab. Phye. t. 8, p. 25, pl. 51 in herb. Kützing.
Amphiroa dilatata Lamouroux, Areschoug in Agardh, Spec. Gen. et Ord. Alg. 1851.
Amphiroa galaxauroides Sonder, Plantae Preiss. vol. 2, p. 188 in herb. Kützing.
Amphiroa ephedraea in Harvey, New South Wales Algae N°. 458!
Amphiroa ? in Ferguson, Ceylon Algae N°. 119! 224! 442!.

Stat. 33. Pidjot Bay, Island Lombok.
Stat. 307. Bay of Endeh, Island Flores.
Sikka, Flores. leg. A. Weber-van Bosse 1888.
Southcoast Java, leg. Teysman.

Fronds branched dichotomously at top of broadened joint, rarely trichotomously, with adventitious branches springing from the joints not from the nodes; joints flattened, two-edged, at base of plant sometimes cylindrical and sometimes much flattened and broadened; upper joints almost always flattened, rarely a cylindrical joint between flat ones. The top joints as a rule a little fan-shaped, distinctly zonate, less so if top joint is, — as seldom happens — almost cylindrical or bears conceptacula.

Central strand of 2, 3, 4 or 5 rows of long cells, followed by a row of very short cells. Height of long cells from 36—140 μ, height of short cells 12, 16, 20 μ. Rows of cells spreading fan-like from the centre towards the periphery. Cortical layer relatively thin except in old joints.

When the broadened top joint is going to divide, there appear two little short cylinders of non-calcified tissue consisting of a part only of the central strand. These short cylinders are to be the two nodes; the cells constituting the nodes increase slightly in number, thicken their membranes and grow till they have the size of the adult node. The remaining portion of the central strand and the cortical layer adhering to it, remain calcified and separate around the nodes.

Three little teeth of calcified tissue surround the base of the two nodes, one at each side and one in the middle. The node itself is however later on surrounded by a young layer of non-calcified cortical cells, and by their repeated divisions the node increases in thickness with the thickness of the frond. In some specimens the two nodes touch one another at the base and no little tooth of calcified tissue is observed between the nodes which are then practically only one node at their base, which divides in apical direction into two portions.

Conceptacula appear as a rule only on one side of the joint, but sometimes on both sides. They are slightly prominent and have a diameter from 250—410 μ. I have seen conceptacula with tetraspores and with antheridia.

Amphiroa anceps was described by LAMARCK under the name of *Corallina anceps* from New Holland; a few years later LAMOUROUX described the same alga from the Cape under the name of *A. dilatata*. ARESCHOUG pointed out the great affinity between *A. dilatata*, *anceps* and *Bowerbankii* but maintained the three species. My collections give me entire justification for sinking *A. dilatata* in *A. anceps*, which name as the older one must be maintained. The joints of *A. anceps* differ so much, even on the same plant or on different plants from the same locality, that the limits must be made very large. Specimens with long, flat, zonate joints, with nodes having three little teeth and with conceptacula in two rows on one side of the joint will be found intermingled with joints with obtuse border, not so compressed and without the characteristic teeth.

The nodes of all these plants have this in common that they consist of a part of the central strand. The two nodes in one articulation may remain isolated each by itself or adhere together at their base, and this may be observed even in the same plant. The cortical layer adhering to the nodes increases in thickness with the thickness of the frond and can in old fronds attain a considerable dimension.

The central strand is built up of two, three, four or five rows of long cells followed by a row of shorter cells and then a row of very short cells 8—12 μ high. These two latter rows are not always to be found, sometimes there is only one row of 20—40 μ high. The

conceptacula are sometimes very big, 410 μ in diameter, sometimes much smaller. I thought their size might perhaps give a good specific character but since I found on one joint conceptacula of 300 μ and others of 400 μ, I feel doubtful as to the value of this character. I believe that all the above given synonyms belong to *A. anceps*, or it might be that the plants when studied in detail at the spot where they are growing, will reveal constant differences that escape me now; for the present I feel inclined to explain the existing differences in form of joint etc. by influences of the environment. *A. anceps* is highly variable in its colour. Dried specimens of very different hue have passed through my hands, but this cannot be considered as a specific character.

5. *Amphiroa Bowerbankii* Harv. Pl. XIV, fig. 14—17.

Harvey. Nereis Australis p. 97, tab. XXXVII.
Kützing. Tab. Phyc. t. 8, tab. 50. (The little dots of calcareous tissue on the nodes are not given in the figure).
Areschoug in J. G. Agardh. Spec. Gen. et Ord. Alg. t. II, 1851.

Southcoast of Java. leg. Teysman.

Fronds branching di- or trichotomously from broadened top of last joint, with adventitious branches springing from the joint not from the node; joints at base of plant either cylindrical or broad and flattened, more or less canaliculate with central strand protruding below, winged with undulating border. Upper joints flattened, border slightly undulated or two-edged, in well-grown specimens distinctly zonate.

Central strand consisting of 2, 3, 4 rows of long cells 56—108 μ high, followed by a row of short cells 8, 12, 40 μ high. Cortical layer thicker than in *A. anceps*. Nodes appear as in *A. anceps* in the broadened part of the last joint and consist of a non-calcified part of the central strand and of the cortical layer adhering to it. The other calcified part of the central strand splits as does also the cortical layer. From the uncalcified cortical layer of the node spring forth 1—7 little dots of calcareous tissue, sometimes covering the node almost entirely. Conceptacula slightly prominent or subimmersed in the cortical layer, diameter from 360—460 μ.

Amphiroa Bowerbankii is closely allied to *A. anceps* but it can be easily distinguished from this latter alga. As a rule it is broader, its cortical layer thicker, its conceptacula less prominent than in *A. anceps*, but the character by which it is most easily known are the nodes which are characterized by little dots of calcareous tissue. These will sometimes fail, though as a rule I believe, that on carefully searching a plant apparently without dots, one is almost always sure to find at least a single dot, indicating the species to which the plant belongs. The joints at the base, when they are not cylindrical, can be as broad as 1 cm. and these broad joints have an outward likeness to the joints of *A. canaliculata*. I once thought that plants with such broad joints, might be an intermediate form between *A. Bowerbankii* and *A. canaliculata* and wrote in this sense to Mr. YENDO [1]) but specimens that I got later on

1) K. YENDO. Enumeration of corallinaceous algae hitherto known from Japan. — Bot. Mag. of Tokyo, vol. XVI, n° 189, Nov. 1902, p. 6.

convinced me that plants of *A. Bowerbankii* can have broad joints and still have nothing really in common with *A. canaliculata*. *A. anceps* can also have broad joints at its base though not nearly as broad as I have seen them in *A. Bowerbankii*.

The central strand has, just like the central strand of *A. anceps*, 2, 3, 4 rows of long cells from 80—100 μ long. These are followed by a row of shorter cells from 20—40 μ long, and then comes a row of very short cells from 8—12 μ long. The latter two rows are not always developed, sometimes one finds only one row of ± 20 μ high. The cells of the central strand spread fan-like from the centre towards the periphery; the cortical layer is thicker than in *A. anceps*, the conceptacula are often more or less overgrown and appear therefore smaller than in *A. anceps* but they are really not smaller. As a rule they cover one side of the joint but I found them frequently on both sides.

On Pl. XIV are figured two nodes of *Amphiroa Bowerbankii*; fig. 17 shows us the node in a young stage seen from above, fig. 16 in longitudinal section. On the same plate we see a node of *A. exilis* and *A. ephedraea* and on Pl. XVI, fig. 7 and 8 a node of *A. anceps*. *A. exilis* was not amongst the plants of the Siboga collection, but I thought it worth while to have its node figured, because these four nodes show clearly how with small variations a distinctly different node is formed. In *A. anceps* and *A. Bowerbankii* the node is formed of a part of the central strand and a part of the cortical layer, in *A. exilis* the whole central strand and a part of the cortical layer take part in the formation of the node, and in *A. ephedraea* the node is built up of the entire central strand and the entire cortical layer. In the manner in which the long and short cells alternate in these four species and in the fan-like spreading of the cells from the centre towards the periphery, there is another indication of their close relationship. All the above named four species occur on the East coast of South Africa and at least three of them along the coast of New Holland and intervening regions.

6. *Amphiroa ephedraea* Lamck. Pl. XIV, fig. 13.

Corallina ephedraea Lamarck, Mem. du Mus. II, 1810, p. 238.
Amphiroa Gailloni Lamouroux, Pol. flex. t. XI, 1816, p. 298.
Amphiroa fusoides Lamouroux, Pol. flex. t. XI, 1816, p. 298.
Amphiroa ventricosa Lamouroux, Sec. Decaisne.
Amphiroa ephedraea Lamarck, Harvey Nereis Austr. t. XXXIX, p. 95.
Amphiroa Gueinzii Harvey, Nereis Australis, t. XXXIX, p. 95.
Amphiroa Pöppigii Endlicher et Diesing.
Amphiroa ephedraea Lamarck, Areschoug in J. G. Agardh, Spec. Gen. et Ord. Alg. 1851, p. 534.
Amphiroa ephedracea Decaisne, Kützing, Tab. Phyc. t. 8, tab. 47.

Benkulen, Sumatra. de Bril. leg. Snackey.

Sturdy plants, fronds branching dichotomously, branches spreading; joints at base of plant cylindrical or compressed; upper joints cylindrical or a little compressed, many times longer than broad. Central strand consisting of 2, 3 rows of elongated cells from 60—118 μ high, followed by a row of shorter cells from 20—40 μ high, which again is followed by a row of very short cells from 8—12 μ high. Sometimes one finds only one row instead of two, which has a height from 20—40 μ. Node consists of entire central strand and cortical layer, which

grows in thickness with the thickness of the frond. In the node I observed from 7—13 rows of alternately long and short cells.

Conceptacula big; slightly prominent, subimmersed in the frond. Diameter of conceptacula from 300 μ to 1 mm. Tetraspores from 90, 120 to 160 μ long.

Amphiroa ephedraea is on account of its size one of the most easily known *Amphiroae*. Small or dwarf specimens may give some trouble, but the structure of the node is a ready help to recognise the species. The whole central strand and the whole cortical layer take part in its formation, and the branching does not always take place at the node, but sometimes a little below it. The cells constituting the node are short when the node is young, but increase in length for a long time; I found cells at the base of the plant from 160—190 μ long. I do not think however that the number of cell-rows increases in any node; I believe these to remain the same in each node and not to change from the moment the node is formed. The conceptacula and tetraspores of *A. ephedraea* are the biggest I have seen in this genus. In longitudinal sections the conceptacula are seen to be immersed in the frond though, on account of their size, they rise also above the frond.

In KÜTZING's herbarium is a specimen called *A. linearis* Kützing from Senegambia which I think is a stunted form of *A. ephedraea*. The nodes are like those of this alga only rather short, and the top joints are a little flattened as in *A. Beauvoisii* Lamx. (*exilis* Harv.). The material at my disposal is however far too little to allow me to express myself with more certainty. It is highly desirable that naturalists should collect *Amphiroa* in well-grown specimens to enlighten the study of these variable plants.

7. *Amphiroa canaliculata* von Martens. Pl. XVI, fig. 9—12.

Von Martens. Die Preussische Expedition nach Ost-Asien. Bot. Theil. Die Tange 1866, p. 28.
Yendo. Corallinae verae Japonicae Tokyo, 1902.

Stat. 33. Pidjot Bay. Island of Lombok.
Stat. 34. Bay of Labuan-Pandan. Island of Lombok.

Fronds articulated, spreading over the substratum, branching dichotomously, branches much diverging; joints broad, winged; upper side convex, under side canaliculate with a prominent midrib. Adventitious branches rare. Fronds consisting of central strand and cortical layer. Central strand forms the prominent midrib and also the node and is built up of 4 or 5 rows of long cells 80—90 μ followed by a row of short cells ± 28 μ; cortical layer strongly developed forms also the wings of the joints which are turned downward and sometimes meet and coalesce. Node consists of central strand and a portion of the cortical layer which grows in thickness with the thickness of the joints; conceptacula on both sides of the joint, overgrown by the cortical tissue. Diameter 320—360 μ. Height of tetraspores 80 μ.

A. canaliculata is a very characteristic plant with its thick broad joints, which have a very distinct midrib along the canaliculate under side of the joint. The node is the continuation of the central strand, that divides dichotomously at the joint, and is surrounded by many layers of cortical tissue. The non-calcified tissue of the node has its greatest development at

the under side of the upper joint as may be seen distinctly in fig. 11 on Pl. XVI. The upper side of the node is covered by overlapping layers of calcified tissue. The cortical layer has a very great development in the joint; the conceptacula appear on both sides of the joint but they are only slightly prominent and often entirely immersed by subsequent growth of the frond.

8. *Amphiroa crassa* Lamx. Pl. XV, fig. 1—7.

Amphiroa crassa Lamouroux. Voyage de l'Uranie par Freycinet. Zoologie par Quoy et Gaimard 1824.
Amphiroa Godeffroyi Grunow. Algen der Fidschi, Tonga und Samoa Inseln. In Mus. Godeffroyensis at Hamb. sub nom. *A. robusta*.

Stat. 282. East Point of Timor.
Stat. 303. Haingsisi, Island Samau.
Stat. 304. Lamakera, Island Solor.
Southcoast of Java. leg. Teysman.

Fronds articulated, branching di-trichotomously or irregularly, many joints springing from one broad joint. Adventitious branches arise from the joint never from the node. Central strand built up of one, two or more rows of long cells, followed by a row of shorter cells, very short ones were not observed. Length of long cells from 80—100 μ, of short ones from 32—36 μ. Cortical layer much developed. Node consisting only of the central strand, many rows of cells taking part in its formation. Calcified cortical layer surrounds the node entirely or splits horizontally leaving the node naked for a very short space. When the cortical layer does not split, a little constriction of the frond is the sole indication of the node. Conceptacles superficial, often overgrown by cortical layers and sunk deep into the frond. Diameter of conceptacles 320—340 μ.

I got this beautiful *Amphiroa* first at the East Point of Timor. It is closely allied to *A. tribulus* Lamx, both having the same way of forming their nodes; but whether they belong to one species I could not ascertain; the material of *A. tribulus* that I had at my disposal was scanty and presented quite a different aspect.

A. crassa however is a variable plant; I have specimens 8 cm. high, erect, branching dichotomously and spreading widely, with long, relatively thin joints and other specimens from 2—6 cm. high with short, broad joints. Again other specimens connect both the former specimens in an unmistakeable manner. The specimens with the long joints were described by Grunow as *A. Godeffroyi*.

I believe that a small alga, that I got on a former voyage in the Archipelago at Sikka, Island of Flores, is a dwarf form of *A. crassa*. It has the same way of forming its node and is in all respects like the type but it is not higher than 1—1,5 cm. It may be distinguished as f. *minuta*.

When I began my study on the *Amphiroae* of the Siboga Expedition, I did not intend to write a monograph of the genus. For the sake however of those who would like to name their *Amphiroae*, with reference to the structure of the node, I have made the following key.

The species of which I have only seen one or two specimens and for the specific value of which I would not be held responsible, I have marked with a †.

Synoptical Key

to the species of *Amphiroa*.

I. Fronds thick, cylindrical or flattened but with round edges; ramification dichotomous or irregular; adventitious branches springing from the joint never from the node. Node consisting only of the central strand; cortical layer of calcified tissue splitting horizontally around the non-calcified node or not splitting at all. In this case node outwardly only visible as a narrow constriction of the frond. Conceptacles at first a little prominent afterwards entirely immersed:

1. *Amphiroa crassa* Lamx.
   f. *Godeffroyi* Grun.
   f. *minuta* n. f.
2. *Amphiroa tribulus* Lamx.

II. Fronds flattened, cylindrical, thick with distinct nodes in the structure of which central strand and cortical layer take part. Nodes sometimes larger at the under side than at the upper side in *A. canaliculata*; cortical calcified layer of upper joint overlaps in older joints the node and touches the lower joint:

fronds canaliculate. 3. *A. canaliculata* v. Mart.

fronds not canaliculate. 4. *A. involuta* Kütz. (syn. *A. capensis* Aresch.).

III. Fronds cylindrical or flattened with sharp thin edges; ramification dichotomous.

a. Nodes usually in pairs consisting of part of central strand and part of cortical layer and appearing at first as two little cylinders at base of joint; when fully developed three small teeth of calcareous tissue, one in the middle and one at each side of the node, are visible:

5. *A. anceps* (Lamk.) Dec.

b. Nodes like those of *A. anceps* but also with little dots of calcareous tissue on the nodes:

6. *A. Bowerbankii* Harv.

c. Node composed of entire central strand and almost entire cortical layer; with only two little teeth of calcareous tissue one at each side of the usual single node:

7. *A. Beauvoisii* (Lamx.) Born.
   ? *A. zonata* Yendo.
   ? *A. echigoensis* Yendo.
   ? *A. pusilla* Yendo.

d. Node consisting of entire central strand and entire cortical layer. No little teeth of calcareous tissue at base of node:

8. *A. ephedraea* (Lamk.) Aresch.
† 9. *A. linearis* Kütz.

IV. Fronds cylindrical, joints swollen padlike at top and base or not swollen in a young state and never in *A. anastomosans*; rows of cells in central strand almost horizontal not curved. Nodes consisting of entire central strand and cortical layer, swollen cushionlike to bear the joints or not swollen in a young state, and obsolete never swollen in *A. anastomosans*. Conceptacles very prominent:

10. *A. fragilissima* Lamx.
    f. *fragilissima* Lamx.
    f. *cuspidata* Lamx.
    f. *cyathifera* Lamx.
11. *A. anastomosans* n. sp.

V. Fronds flattened winglike with undulating border, or almost cylindrical with a narrow border or sometimes none; rows of cells in central strand curved, above all in winged specimens, not horizontal. Nodes of entire central strand and cortical layer as broad in most cases as the frond but not swollen cushion-like. Conceptacles not or slightly prominent, half immersed in the tissue of the frond:

12. *A. foliacea* Lamx.

VI. Fronds cylindrical. Nodes consist of central strand; cortical layer splits or takes part in the formation of the node. Conceptacles prominent, half immersed or — in old plants — entirely sunk in the cortical layer:

a. Node consists of one layer of cells of the central strand:

13. *A valonioides* Yendo.

b. Node consists of one layer of long cells and one layer of short cells of the central strand and as a rule also of the cortical layer:

14. *A. verrucosa* Kütz. (syn. *A. cryptarthrodia* Zan.).

c. Node consists of two layers of cells of equal length, with oblique anticline walls, cortical layer splits:

15. *A. rigida* Lamx.

d. Node of three layers of cells of equal length; cortical layer splits:

16. *A nodulosa* Kütz.

e. Node of three or more layers of cells, alternately one long and one short, or two long and one short; irregular. Cortical layer splits or partially takes part in the formation of the node by secondary growth:

17. *A. dubia* Kütz.

I should like to add a few remarks for the clear understanding of some species mentioned in this Key.

To *Amphiroa Beauvoisii* (Lamx.) Born., which species includes according to ARDISSONE [1]) and BORNET [2]):

A. exilis Harv.
A. pustulata Mert.
A. complanata Kütz.
A. polyzona Mont.
A. algeriensis Kütz.

must also be reckoned *A. brasiliana* Dec. All these plants have the same structure of node.

1) F. ARDISSONE. Phycologia mediterranea 1883.
2) E. BORNET. Les algues de P. K. A. SCHOUSBOE. Paris 1892.

Almost the same structure occurs also in an alga in SURINGAR's herbarium called *A. peruanae* Aresch. I have not been able to find the diagnosis of ARESCHOUG for *A. peruanae*. Perhaps it is only a herbarium name and therefore without value. My specimen is barren but the plant is so sturdy that I must leave it to others to decide whether this plant is a separate species or a variety of *A. Beauvoisii*. It differs in the structure of its node so far as this, that it is very distinctly semi-lunar.

To *A. rigida* Ardissone refers:

A. spina Kütz.
A. irregularis Kütz.
A. amethystina Zan.
A. cladoniaeformis Men.

I have not seen *A. amethystina* Zan. but the three others named pseudo-species had all the same structure of node as the typical *A. rigida*. This same structure of joint and node occurs also in a specimen in the herbarium of Prof. SURINGAR which was collected by him in the West Indies. It is characterized by widely spreading, dichotomous, intricate branches and may well be distinguished as f. *divaricata* pl. XVI, fig. 13. I have not seen a single type specimen of *A. parthenopea* Zan. and cannot decide whether it is a synonym of *A. rigida* as BORNET, or of *A. complanata (exilis)* as SOLMS-LAUBACH affirms.

A. verrucosa was described by KÜTZING in 1843 in his Phycologia generalis; he changed this name afterwards into *verruculosa*, probably because the name of *verrucosa* had already been given by LAMOUROUX to a species of *Amphiroa*. We shall however see in the following pages that *Amphiroa verrucosa* Lamx. is not an *Amphiroa*, and therefore the old name of KÜTZING may be revived. SOLMS-LAUBACH has described *A. verrucosa (verruculosa)* Kützing and *A. cryptarthrodia* Zan. as two distinct species. They have however exactly the same structure of joint and node and I consider them therefore as identical. *A. verrucosa* Kütz. as being the older name, must be maintained.

Though I have not seen *A. valonioides* Yendo, the node of this alga is so well figured by YENDO that I was able to classify it in this key. I have neither seen *A. zonata* Yendo, *A. echigoensis* Yendo nor *A. pusilla* Yendo. According to the figures they seem to belong all three to the genus *Amphiroa* and to stand near to *A. Beauvoisii* and *A. peruanae*, but as YENDO has not given a figure of the node, I do not dare to express myself with greater certainty.

Amphiroa misakiense Yendo is probably an *Arthrocardia*.

Metagoniolithon n. g.

Pl. XV, fig. 9—14.

The genus *Metagoniolithon* though it was not found in the collection of the Siboga Expedition may well be treated here, for my researches on the *Amphiroae* of the Siboga led me to create this genus. It has been characterized in the Synoptical Key on p. 86. It is distinguished from *Amphiroa* as we have already seen by the anatomical structure of the joint and node. The cells are of a uniform size throughout the whole joint, only growing

gradually a little smaller towards the node where the cells are relatively very small and thick-walled. In the growing apex the node is already visible as a mass of small cells (Pl. XV, fig. 11).

From the node, which increases in thickness with the thickness of the frond, spring forth the branches and in one species of this genus *M. stelligerum* the node, the cells of which struck me as not being particularly small, increases also in length. This takes place through the cells of the central strand of the calcified joint losing their chalk where they are in contact with the node. At the periphery of the central strand cell division takes place which causes the still calcified cortical layer to be thrown off, either partially or in old plants almost entirely.

By this process the articulated appearance of the young plant disappears gradually and a long pliable horny branch is seen with remnants of the calcified cortical layer adhering to it here and there. Such forms of *M. stelligerum* were described by LAMOUROUX as *Amphiroa jubata* and *A. interrupta*. Sectioning the horny node of such plants I was struck by the total disappearance of what everybody is used to consider as the typical structure of the *Melobesiaceae*. The cells of the central strand were no longer standing in straight rows one above another as they had done in the young plants. They now had thick walls, had been pulled in various directions and the places where their protoplasts clung together, had grown out, giving very different shapes to the cells, which looked in fact like any ordinary small-celled alga-tissue, such as one meets in so many *Florideae*. The cortical layer consisted of rather large cells, horizontally stretched and growing smaller towards the periphery.

I have dwelt at some length on this structure of old plants of *M. stelligerum* because it explains the structure of my new genus *Litharthron*. *M. stelligerum* is the link between *M. charoides* and *Litharthron australis*, but it has more characters in common with *M. charoides*. Young plants in fact of *M. stelligerum* have the same anatomical structure as *M. charoides*; it is only with increasing age that such characters appear which we shall find again, only still further developed, in *Litharthron australis*.

The three species of the genus *Metagoniolithon* are:

1. *M. charoides*.

Amphiroa charoides Lamouroux, Hist. d. Pol. flexibles, 1816, p. 301.

Sturdy plants with branching fronds, distinctly articulate. Joints often a little flattened from 1 to 3 cm. long and up to 2 mm. broad. Nodes rather short, entirely surrounded by pseudo-whorls of branches, no true whorls, for the branches do not appear simultaneously. Anatomical structure of joint consists of many layers of cells all of the same dimension, the cells of each horizontal row communicating by thin places in the longitudinal wall. In the node the cells are very small and have thick walls. Fructification consists of conceptacula, which appear first on the inner side of the branches but may afterwards cover the whole branch.

This plant is found in South Australia; the specimens which I received under the name of *Amphiroa charoides* from the West Indies belonged to *Amphiroa foliacea*. I therefore do not know, whether specimens of *M. charoides* have indeed been found in that region.

2. *M. graniferum.*

Amphiroa granifera Harvey, Phyc. austr. pl. CCXXX. Syn. Cat. 1863, p. XXX.
Amphiroa intermedia Harvey.
Amphiroa stellata Kützing, Spec. Alg. 1849.
Amphiroa similis Sonder, Bot. Zeit. 1845.
Amphiroa setacea Kützing, Spec. Alg. 1849.

Plants with branching, distinctly articulate fronds. Joints cylindrical up to 0,5 cm. long and at the utmost 1 mm. broad. Nodes surrounded by a tuft of branches like whorls, no true whorls just as in *M. charoides*. Anatomical structure of joint consists of many layers of cells all of the same size, the cells of each horizontal row communicating by thin places in the thin walls.

In the nodes the cells are very small and thick-walled.

Fructification consists of conceptacula, that appear first on the inner side of the branches but afterwards cover the whole branch.

A. similis Sond. is only distinguished from *A. granifera* Harv. by its smaller size. Of *A. setacea* Kütz. there is only a very small specimen in KÜTZING's herbarium. I think it probable, that this plant belongs also to *M. graniferum* but I am not quite sure. It has the same anatomical structure as *M. graniferum*.

M. graniferum is an inhabitant of the Australian seas: the plant called *Amphiroa setacea* was found on the coast of Peru.

3. *M. stelligerum.*

Corallina stelligera Lamarck, Mém. du Musée II, p. 239.
Amphiroa stelligera (Lamk.) Areschoug, Die Corallineae in Agardh's Spec. Gen. & Ord. Alg. 1851, p. 540.
Amphiroa jubata Lamouroux, Hist. polypiers flex. 1816.
Amphiroa interrupta Lamouroux, Hist. polypiers flex. 1816.
Amphiroa verrucosa Lamouroux, Hist. polypiers flex. 1816.
Amphiroa elegans Sonder, Bot. Zeit. 1845.

Long, slender plants with branching fronds; distinctly articulate when young, less so in old plants. Branches whorl-like, very slender. Old plants often drop their calcified cortical layer and slender branches.

Anatomical structure of the young joints consists of many rows of cells, all of the same size. In the nodes the cells are very small, thick-walled and take various shapes above all in old plants, where the central layer of the joint loses its chalk and where, by subsequent divisions of a layer of cells surrounding the central strand, the calcified cortical layer is thrown off and a new cortical layer formed. This process gives rise to the cup-like swellings we often see at the top and base of nodes of *M. stelligerum* pl. XV, fig. 9.

Conceptacles on the branches. This species may have a very different appearance according to whether the cortical layer has fallen off or not. Plants that were rather bare or had only slender, scattered branches were called *A. jubata* or *A. interrupta* by LAMOUROUX. I believe that *A. verrucosa* is also a synonym of this species. ARESCHOUG gives the name as a synonym of *A. charoides* but he adds, that he has not seen the authentic specimen. Under the name of *A. verrucosa*

we find two specimens in LAMOUROUX's herbarium. One is *A. stelligera* Lamk.; the other is identical with *A. similis* Sond. The first specimen has "bourrelets aux deux extrémités" as LAMOUROUX called the swelling at the top and at the base of the joints in his *A. verrucosa*, swellings which however are not always to be found there and often disappear in old age. On account of these "bourrelets", I think that *A. verrucosa* may be taken as a synonym of *M. stelligerum*. *A. stellulata*, which ARESCHOUG gives as a synonym of *A. charoides*, I believe to belong to *M. graniferum*.

M. stelligerum is like the two other species an inhabitant of Australian seas.

Litharthron n. g.

Pl. XVI, fig. 16, 17.

The alga known as *Amphiroa australis* belongs, different as its anatomical structure may be, to the *Corallineae*. This difference was first observed by KÜTZING, to whose sharp eyes little indeed escaped that concerned algae. He was so much struck by the aberrant structure of *Amphiroa australis*, that he expressed his doubts as to whether it could be kept amongst the *Amphiroae*.

My studies have taught me, that *Amphiroa australis*, for which I propose the name *Litharthron australis*, must be kept in the family of the *Corallineae* and that its place is — different as their outward appearance may be, — close to *Metagoniolithon stelligerum*. Some of the characters which distinguish this latter plant, only still further developed, are also the characters of *Litharthron*. The cells of the central strand in the joint are non-calcified, just as in old plants of *M. stelligerum*, but in *L. australis* these cells are intricated and imbedded in a mucilaginous layer. The cells of the cortical layer of *L. australis* are big, calcified, thin-walled, filled with starch near the central strand and becoming gradually smaller towards the periphery; in *M. stelligerum* the primary cortical layer of calcified cells is thrown off; the secondary cortical layer has round, big cells growing smaller towards the periphery but they are non-calcified and thick-walled. I do not know the nature of the mucilaginous layer in which the central strand of *Litharthron* is imbedded but after putting thin sections of this plant on a slide with a drop of sea-water, I saw the central part of the section swell up. With the polariser numerous brilliant spots were visible to the right and left of this central layer, which itself remained quite dark under the crossed nicols. But it was not the whole central strand that was non-calcified; at its periphery I saw distinctly long cells imbedded in a layer that contained chalk.

In the node the cells were of different size, and presented the aspect of an ordinary *Florideae*-tissue; here also a distinct cortical layer was visible. From the node spring the branches as in the different species of *Metagoniolithon*. The flatness of the node is a character of small importance, but it is a great help towards recognizing *L. australis* at once amongst a collection of *Corallineae*. I fancy however that in a living state the flatness of the joint would be less remarkeable, owing to the mucilaginous layer in the middle of the joint being then swollen.

The conceptacles have not yet been found; I can only hope that they may soon be discovered and that they will confirm my views about the genus *Litharthron*.

Litharthron, just like *Metagoniolithon* is an inhabitant of the Australian seas. It has

only one species *Litharthron australis* Sonder, which has the same diagnosis as the genus. HARVEY in his Account of the Marine Botany of the Colony of Western Australia mentions under N°. 155 an *Amphiroa* sp. . . . , growing with *A. australis*, to which it is allied. This specimen had however become broken in travelling. It would be interesting to know, whether this plant of HARVEY is indeed another representative of the genus *Litharthron*.

Arthrocardia (Dec.) Aresch.

Though there were no specimens of the genus *Arthrocardia* in the collection of the Siboga, I should like to say a few words about this genus as my researches on the *Amphiroae* of the Siboga led me to sink many species into the genus *Arthrocardia* that had hitherto been considered as belonging to the genus *Amphiroa*.

The genus *Arthrocardia* has been sunk by SCHMITZ and HAUPTFLEISCH into the genus *Cheilosporum*. However not only these two genera but the four genera *Arthrocardia*, *Cheilosporum*, *Corallina* and *Jania* are closely allied together, much closer indeed, than either of them to the genus *Amphiroa*. They are probably a separate branch of the family of the *Corallineae*, just like *Amphiroa* and *Metagoniolithon*, but I have not been able to trace the common ancestor of these four first-named genera.

Their anatomical structure is almost the same; in *Jania* alone the cells have nearly the same length in the joint and in the node, which they do not have in the other genera. But there are species of *Jania* which have longer cells in the node and seem to bridge over the difference. The position of the conceptacula however marks a difference between the genera: in *Arthrocardia* we find conceptacula on the joints as in *Amphiroa*; in *Cheilosporum* we find them immersed in the margin of the broadened, winglike joint, in *Corallina* and *Jania* immersed in the frond at the top of the joints.

We see three stages, each marking a gradation of higher development and I think that the different names may be kept to mark the different stages. Whether they must be considered as names of genera or only of subgenera will depend upon the value one attaches to a character depending upon the position of the conceptaculum and upon the conception one has of a genus.

To *Arthrocardia* belong the following species considered by late authors on the subject to belong to the genus *Amphiroa*:

1. *Arthrocardia cretacea* (P. et R.).
   Corallina cretacea P. et R.
   Amphiroa cretacea (P. et R.) Aresch.
2. *Arthrocardia tuberculosa* (P. et R.).
   Corallina tuberculosa P. et R.
   Amphiroa tuberculosa (P. et R.) Setchell and Gardner.
3. *Arthrocardia epiphlegnoides* (Ag.).
   Amphiroa epiphlegnoides Ag.
   Amphiroa rudis Harvey.

I saw this specimen at the British Museum and I think it very likely, that it is only a form of *A. tuberculosa* as YENDO supposed in his paper on the *Corallinae* of Port Renfrew.

4. *Arthrocardia aberrans* (Yendo).
Amphiroa aberrans Yendo.
5. *Arthrocardia declinata* (Yendo).
Amphiroa declinata Yendo.
6. *Arthrocardia variabilis* (Harvey).
Amphiroa variabilis Harvey.
7. *Arthrocardia Darwini* (Harvey).
Amphiroa Darwini Harvey.
8. *Arthrocardia vertebralis* Dec.
Amphiroa vertebralis Aresch.
9. ? *Arthrocardia breviarticulata* (Aresch.).
Amphiroa breviarticulata Aresch.

I have in the herbarium of SURINGAR a specimen called *Amphiroa breviarticulata* Areschoug which seems to be an authentic specimen. This plant is however an *Arthrocardia*. I have tried in vain to see the type of *A. breviarticulata* and have therefore querried the species.

I have not seen a specimen of *Amphiroa crassissima* Yendo but I feel almost sure that this alga belongs to the genus *Arthrocardia*.

All these plants are distinguished from *Amphiroa* by their nodes, which consist of one row of pericline cells which, when fully developed, have a length from 200 to 350 μ and even more, while the cells in the joints have as a rule a length of 60 μ.

YENDO has given very good figures of the nodes and some layers of the joint of *Arthrocardia aberrans* and *Amphiroa rigida* but he has failed to grasp the importance of what he was illustrating.

Cheilosporum (Dec.) Aresch.

In the collection of the Siboga was one species of *Cheilosporum* to which was added a specimen not yet known from the Indian Sea, and collected by TEYSMAN, the well-known Indian botanist.

1. *Cheilosporum spectabile* Harv.

Harvey. Friendly Islands Algae N°. 31.
Grunow. Alg. d. Fidschi u. Samoa Ins. p. 41.

Stat. 78. Lumu-Lumu-shoal, Bank of Borneo.
Stat. 81. Island Sebangkatan.
Stat. 129. Karkaralong Islands.
Stat. 133. Lirung, Karakelang Islands.

Plants with slender or robust fronds, branching dichotomously, forming thick tufts in the littoral region, but straggling and creeeping in deeper waters of 34—36 m.

Breadth of flattened frond from 0,5 to 3,5 mm., apex attenuated, roundish, sometimes cylindrical in specimens brought up with the trawl.

Lobes inserted with broad basis with acute, truncate, dentate, thin apex.

Central strand much developed with protruding midrib, especially in specimens from deeper water, in which even the lobes may be entirely wanting for a fairly long distance. Fructification consists of conceptacles at the acute top of the lobes immersed in the frond; either single or in pairs.

As far as I know, no diagnosis had been given by HARVEY of this widely distributed alga. It is to be found in the Indian and Pacific Oceans and adopts many forms according to the depth in which the specimen grows. The specimens that came up with the dredge were very slender and several of them had attached themselves to other algae on which they were creeping.

The specimens of HARVEY from the Friendly Islands are more robust than those of the Siboga. The specimens distributed by GRUNOW from Upola connect the two forms and take up an intermediate position between the two.

According to GRUNOW *C. spectabilis* Harv. much resembles *Amphiroa multifida* Kütz., whether the two are identical I do not dare to decide.

2. *Cheilosporum jungermannioides* Rupr.

Postels & Ruprecht. Illustr. Alg. Oc. Pacifici 1840.

Southcoast of Java. Teysman.

After careful examination of the type of *Cheilosporum jungermannioides*, I felt convinced that the plant from the South-coast of Java is identical with it.

Corallina Lamx.

1. *Corallina pilifera* Lamx.

Lamouroux, Pol. flexibles. Caen 1816.
Areschoug in Agardh's Spec. Gen. et Ord. Alg. 1851.

Stat. 169. Atjatuning, New Guinea. On dead branches submersed in the sea.

This *Corallina* is probably only a form of the highly variable *C. Cuvieri* Lamx.

Jania Lamx.

1. *Jania adhaerens* Lamx.

Lamouroux, Pol. flex. 1816.
Areschoug in Agardh, Spec. Gen. et Ord. Alg, 1851.
Kützing, Tab. Phyc. t. 8, pl. 83*g*.

Stat. 78. Lumu-Lumu shoal, Borneo-bank.
Stat. 172. Gisser.
Stat. 225. Lucipara-group.

2. *Jania rubens* (L.) Aresch.

Corallina rubens (Linn.) Ellis et Solander p. 120.
Areschoug in Agardh, Spec. Gen. et Ord. Alg. 1851, p. 557.
Kützing, Tab. Phyc. t. 8, pl. 84, VIII.

Stat. 33. Bay of Pidjot, Island Lombok.
Stat. 193. Sula Besi Island.

3. *Jania tenella* Ktzg.

Kützing, Tab. Phyc. t. 8, pl. 85 II.
Grunow, Die Alg. d. Fidschi, Tonga u. Samoa Ins. erste Folge p. 42.

Stat. 155. Waigeu Island.
Stat. 193. Sula Besi Island.

Of *Corallina* the Siboga brought home only one species, of the subgenus *Jania* three species; but it proved easier to say that a plant belonged to the subgenus *Jania*, than to say to which species of *Jania* it belonged. In all the above-named three species the length of the cells in the node was fairly equal to the length of the cells in the joint. The rows of cells in the joint were not always of such equal length as one would suppose from our fig. 16 on pl. XVI which is not entirely correct in this respect. The rows were usually more like fig. 18 on the same plate.

I have tried hard to name the three species rightly but these slender forms are so extremely puzzling, that I may still have been mistaken.

Lithothrix Gray.

Pl. XV, fig. 15.

Lithothrix is quite an aberrant genus on account of its calcified constrictions that take the place of the horny nodes in all the other genera of the *Corallinae verae*. Its only species, known as *Lithothrix aspergillum* Gray, has the same diagnosis as the genus. It is an inhabitant of the West Coast of America.

The synoptical Key of the Genera has been made with a view to facilitate for students the determination of the *Corallineae verae*; the outward characters, so far as they coincided with internal ones, have been used as has also the anatomical structure of the frond and the node. The order in which the different genera are enumerated in this Key, gives no idea of their relationship. I believe that these genera, which are outwardly so much alike, have sprung from different members of the group of the Lithothamnioneae. The many affinities existing between *Amphiroa* and *Lithothamnion* have been put forward by Solms-Laubach, the observations of this eminent naturalist have simply been confirmed by my researches, but we have seen at the same time that the old group of *Amphiroa* breaks up into different genera.

It seems to me that just as closely as *Amphiroa* is allied to *Lithothamnion*, so closely is one of the new genera allied to *Goniolithon* and I called it therefore *Metagoniolithon*. In both we find cells of a uniform size, in *Goniolithon* throughout the whole frond, in *Metagoniolithon* with this difference, that the cells in the node are smaller than in the joint; in both, the cells communicate by rather large thin places in their longitudinal walls and in *Goniolithon frutescens* I observed slight constrictions of the frond, that seemed to indicate how easily nature might develop this constriction into the node of *Metagoniolithon*.

In *Goniolithon* however I observed Deckzellen, not quite as such a regular layer as in *Lithothamnion* or *Amphiroa*, but still each apical cell had its own "Deckzelle". In young fronds of *Metagoniolithon graniferum* I did not see any "Deckzellen".

It struck me as very interesting to observe how from two genera so closely allied as *Lithothamnion* and *Goniolithon* had probably sprung forth two genera *Amphiroa* and *Metagoniolithon* which resembled one another outwardly so much and were still so different.

Fossil forms.

The study of the anatomical structure of the *Corallineae verae* afforded the means of recognizing at once in sections of fossil calcareous algae, whether the plants seen in the sections belonged to *Amphiroa* or to either of the other genera. The tissue of the nodes, not being calcified, has always disappeared but the nodes remain visible in the sections as an interruption of the calcareous tissue.

In sections, that I owed to the kindness of Prof. MARTIN at Leiden, I found two plants figured on pl. XVI, fig. 17 and 18. The sections were made from specimens collected on the mountain Nona in Ambon and at Totok in Celebes. The section of Ambon bore the number 327 of Prof. MARTIN's collection; the section from Totok the number 44 coll. FORSTER. Prof. MARTIN was so kind as to tell me that the stratum at Ambon from which the section N^0 327 came, is situated 400 m. above the level of the sea and belongs probably to the pliocene. The stratum at Totok in Celebes, section N^0 44 belongs undoubtedly to the tertiary formation and is certainly not younger than old miocene..

The plant from Totok shows us two half joints and an open space between these two, where most probably the node was to be found when the plant was in a living state. When we compare fig. 18, pl. XVI with fig. 15 on the same plate representing a recent *Jania*, every one can see that the plant from Totok is more like a *Jania* than a *Corallina*.

The length of the node, which is almost the same as the length of the cells in the joint, is a character that points to *Jania*, for the only case that I know of *Amphiroa* having nodes consisting of one row of cells, is *A. valonioides* and here the layers of cells succeeding one another grow smaller and alternate as they should do in an *Amphiroa*; but this they do not do in the plant from Totok.

To which species of *Jania* the plant from Totok stands nearest, I should not dare to decide for the species of *Jania* are very difficult to know from one another, even in a living state. The fact that the subgenus *Jania* occurred already in old miocene, appeared interesting

enough to me, even though I could not make out to what species this old plant belonged or whether it is new to science.

The plant figured in Pl. XVI, fig. 17 is from Ambon; it shows periods of intra-nodal growth so exactly like what one observes in the recent *Amphiroa fragilissima* Pl. XVI, fig. 19 that I do not hesitate to range the fossil alga near that species, even though a node is not visible in the section. *A. fragilissima* is very variable, being slender or coarser in various stages of development; the almost horizontal rows of cells that build up its central strand are however so characteristic that I feel almost sure that the plant of Ambon, which has fairly horizontal rows, belongs to *A. fragilissima.*

In a section from Cape Haharu near the mouth of the Tami-River, New Guinea N°. 734, that I received from Prof. WICHMANN at Utrecht, I found this same *Amphiroa* and also another species. This last one was coarser than the former and the rows of cells in its central strand were decidedly curved. I think it very probable, that this is *A. foliacea*, a species much resembling *A. fragilissima* in the anatomical structure of the frond. In the absence of nodes and conceptacles the determination of both species is however liable to controversy.

In a section from the Island Karas on the western coast of New Guinea, I detected also an *Amphiroa* spec. This section was therefore interesting because, as Prof. WICHMANN told me in a letter, the layer from which it came, certainly dated from the eocene.

PLATES

All the figures plate I—XIII are from photographs in natural size.

PLATE I.

Lithothamnion siamense Fosl. f. *typica*. Fig. 1—2.

Fig. 1. Fertile specimen attached to the shell of a mollusc and in part covering a young crust of another calcareous alga, tube of a worm and the lower part of a small coral. Stat. 49.

Fig. 2. Fertile specimen in company with a young Squamariacea, Bryozoa and corals. Stat. 64.

Lithothamnion siamense Fosl. f. *pseudoramosa*. Fig. 3—9.

Fig. 3. A not quite certain specimen of this form, apparently forming in part a thin crust over another calcareous alga (*Lithothamnion* sp.), attached to the shell of a mollusc. Stat. 234.

Fig. 4—9. Specimens in part covering other calcareous algae (*Lithothamnion* sp.). Stat. 258.

Lithothamnion bandanum Fosl. Fig. 10.

Fig. 10. Specimen surrounding a conglomerate of sand or stone. Stat. 240.

Lithothamnion fragilissimum Fosl. Fig. 11—16.

Fig. 11. An almost entire and fertile specimen of the plant, rather burdened with Bryozoa and other animals. Stat. 81.

Fig. 12—16. Fragmentary specimens which are more or less burdened with extraneous objects, particularly in the part turning downwards. Stat. 81.

Lithothamnion prolifer Fosl. Fig. 17—20.

Fig. 17—18. Specimens not quite typical and somewhat fragmentary, loosely covering a conglomerate of other calcareous algae and animals. Stat. 78.

Fig. 19—20. Typical specimens in part fragmentary, with irregular prolifications. Stat. 81.

Lithothamnion simulans Fosl. f. *crispescens*. Fig. 21—23.

Fig. 21. An intermediate form between f. *typica* and f. *crispescens*, however most nearly connected with the latter. The specimen is attached to a coral. Stat. 299.

Fig. 22. A fertile specimen of the form. Stat. 261.

Fig. 23. A somewhat stunted specimen of the form. Stat. 282.

Lithothamnion simulans Fosl. f. *typica*. Fig. 24—25.

Fig. 24. A specimen rather closely adherent to the substratum: some hard conglomerate and a young *Goniolithon Reinboldi*, the latter fully covered. Lowest to the right on the figure is to be seen a crust of *Archaeolithothamnion erythraeum*, which also is partly covered with the species in question. Stat. 213.

Fig. 25. The plant partly surrounds the branches of a coral, partly expands between the latter. Stat. 213.

PLATE II.

Lithothamnion fruticulosum (Kütz.) Fosl. f. *pteridoides* Fosl. Fig. 1—4.

Fig. 1—2. Specimens with emptied conceptacles of sporangia, the first one with a small and young crust of another species partly covered with the plant. Stat. 240.
Fig. 3. A specimen partly covered with crusts of one or two other calcareous algae. Stat. 123.
Fig. 4. A fertile specimen partly covering another calcareous alga. Stat. 64.

Lithothamnion fruticulosum (Kütz.) Fosl. f. *clavulata* Fosl. Fig. 5—9.

Fig. 5. A specimen apparently forming transition to f. pteridoides. Stat. 240.
Fig. 6—7. Typical or almost typical specimens, especially one of them much burdened however with small crusts of other algae, corals and animals. Stat. 109.
Fig. 8. A similar, but younger specimen. Stat. 250.
Fig. 9. A more delicate and somewhat stunted specimen of the form. Stat. 109.

Lithothamnion australe Fosl. f. *tualensis*. Fig. 10—17.

Fig. 10—17. Young and old specimens of the form. Stat. 258.

Lithothamnion australe Fosl. f. *ubiana*. Fig. 18—24.

Fig. 18—19. Specimens from stat. 86.
Fig. 20—22. Specimens from stat. 99.
Fig. 23. A specimen from stat. 106.
Fig. 24. A specimen from stat. 109.

Lithothamnion australe Fosl. f. *brachiata*. Fig. 25—38.

Fig. 25—30. Specimens from stat. 303.
Fig. 31—32. Specimens from stat. 99.
Fig. 33—34. Specimens from stat. 109.
Fig. 35—38. Specimens from stat. 282.

Lithothamnion australe Fosl. f. *minutula*. Fig. 39—62.

Fig. 39—50. Specimens from stat. 109.
Fig. 51—62. Specimens from stat. 258.

PLATE IV.

Lithothamnion pulchrum A. Web. et Fosl.

Fig. 1—4. Young or rather young specimens of the plant. Stat. 315.

Fig. 5. A specimen partially dead, here and there burdened with small corals, or worms disturbing the tissue, or Bryozoa, the latter in part covered with crustlike formations of the plant. Stat. 315.

Fig. 6. A specimen with the shell of a mollusc between the outermost branches, the shell partly covered with crustlike formations issuing from the said branches. Stat. 315.

Fig. 7—8. Specimens here and there burdened with delicate Bryozoa and other extraneous objects. Stat. 315.

Fig. 9—10. Old specimens of which particularly the first one is much burdened with extraneous objects. These objects are for a great part covered with crustlike formations of the plant which develop even new branches. Stat. 315.

Fig. 11. A specimen the lower part of which is dead. From the upper and living branches issue here and there new layers of tissue, which expand downwards over parts of the dead branches. In this specimen a small and young specimen of the same species has been brought into contact with two of the outermost branches. A crustlike formation some mm. broad has been developed, issuing from both the said branches in a semicircle around one of the branches of the said young specimen, but only in part confluent with the latter. Stat. 96.

PLATE V.

Archaeolithothamniou erythraeum (Rothpl.) Fosl. f. *dura* (Heydr.) Fosl.

Fig. 1. A. piece of the type specimen from El Tor (Ex coll. ROTHPLETZ).
Fig. 2. A piece of an authentic specimen of *Sporolithon ptychoides* f. *dura* Heydr. from El Tor.
Fig. 3—4. Fragmentary specimens from Obock in the Gulf of Aden.
Fig. 5. A specimen surrounding some hard object, forming transition to f. *mollis*. Stat. 193.
Fig. 6. A typical specimen. Stat. 193.
Fig. 7. An older specimen surrounding some hard object, in the part turning upwards rather worn by the action of a strong current. The edges of some of the worn branches are in part covered by new formations of tissue issuing from the undamaged parts of the plant. Stat. 193.
Fig. 8. A specimen with coarse branches, the thickness of the latter is however, at least in part, owing to their covering up extraneous objects, or to new crustlike formations over the primary branches. Stat. 99.
Fig. 9. A similar specimen seen from the side. Stat. 99.
Fig. 10. A specimen with less crowded branches, the thickness of the latter at least in part also owing to their covering up extraneous objects. Stat. 234.
Fig. 11. A specimen almost covering *Goniolithon Reinboldi* attached to a coral. Parts of the latter species with conceptacles are visible at the top and to the right on the figure. East-Indian Archipelago. Stat. unknown.
Fig. 12. A specimen attached to a coral, rather hollowed by worms and much burdened with other foreign bodies. Stat. 234.

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PLATE VI.

Archaeolithothamnion erythraeum (Rothpl.) Fosl. f. *mollis* (Heydr.) Fosl.

Fig. 1. Part of an authentic specimen of *Sporolithon ptychoides* f. *mollis* Heydr. from El Tor.
Fig. 2—3. Young and not typical, rather delicate specimens. Stat. 99.
Fig. 4. A young and typical specimen attached to a piece of coral. Stat. 93.
Fig. 5. An older one. Stat. 220.
Fig. 6. A rather young and somewhat stunted specimen burdened with animals and young crusts of other calcareous algae. Stat. 81.
Fig. 7. A specimen surrounding some small object and rather burdened with animals. Stat. 109.
Fig. 8. A similar one forming transition to f. *dura*. Stat. 172.
Fig. 9. A typical specimen surrounding some hard object. Stat. 96.
Fig. 10. An old specimen. Stat. 71.
Fig. 11. A similar one rather attacked by animals. Stat. 213.

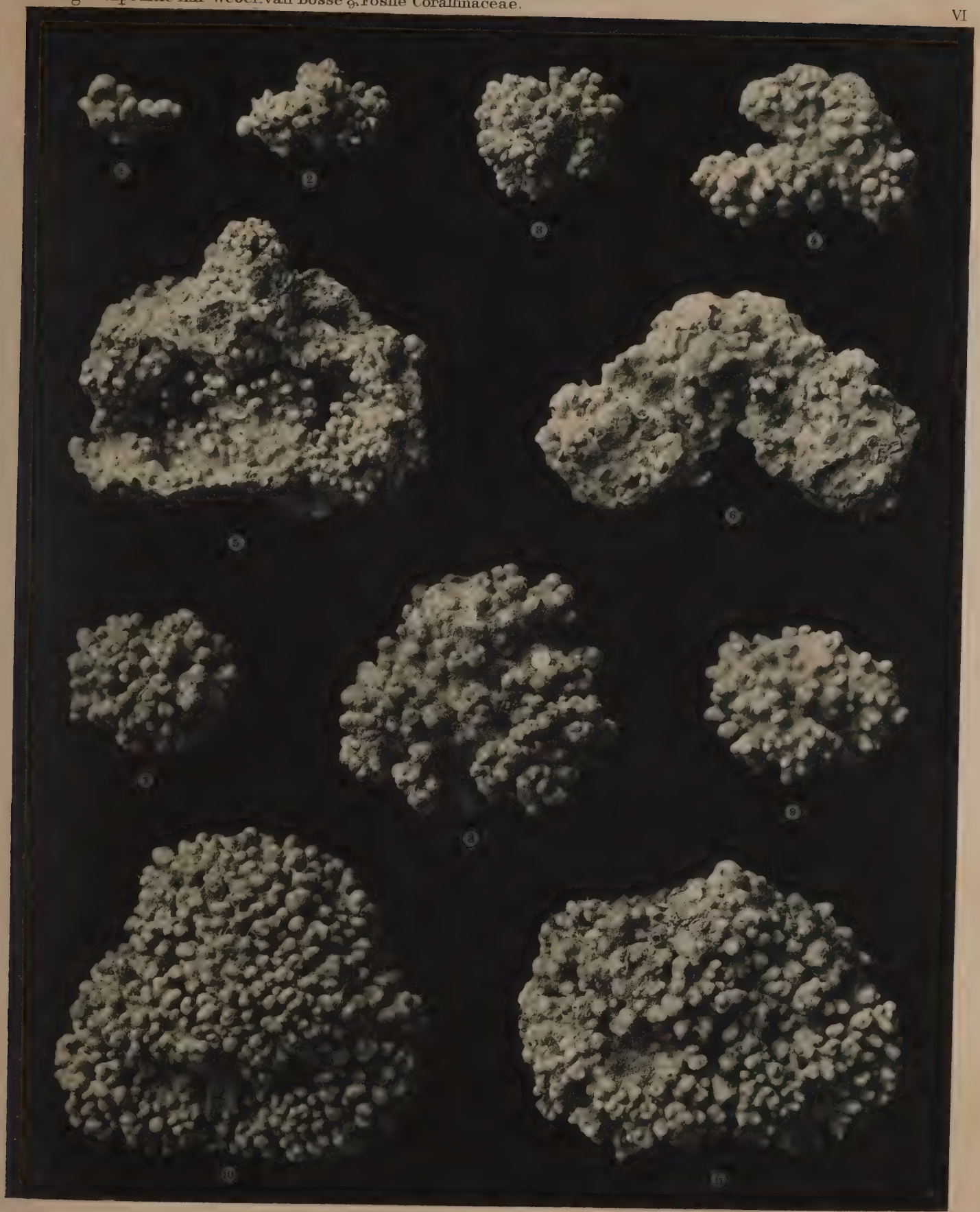
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PLATE VII.

Archaeolithothamnion Sibogae A. Web. et Fosl.

Fig. 1—2. Rather young and not quite entire specimens of the plant. Stat. 99.
Fig. 3—7, 9—12. Partly young, partly older specimens, some of which are rather burdened with extraneous objects, e. g. Bryozoa and sponge-like formations. Stat. 96.
Fig. 8, 13—14. Similar ones. Stat. 99.
Fig. 15. An old specimen rather burdened with foreign bodies, particularly Bryozoa. Stat. 96.
Fig. 16. A specimen partly dead, confluent with a roundish extraneous object and apparently fragments of another species, and also in part covered with other extraneous objects. New layers of tissue, here and there issuing from the living parts, expand partially over the dead parts of the plant and the extraneous objects as new crustlike formations. Stat. 99.
Fig. 17. An old and vigorously developed specimen with thick branches partly owing to covering up foreign bodies, particularly Bryozoa. Stat. 96.

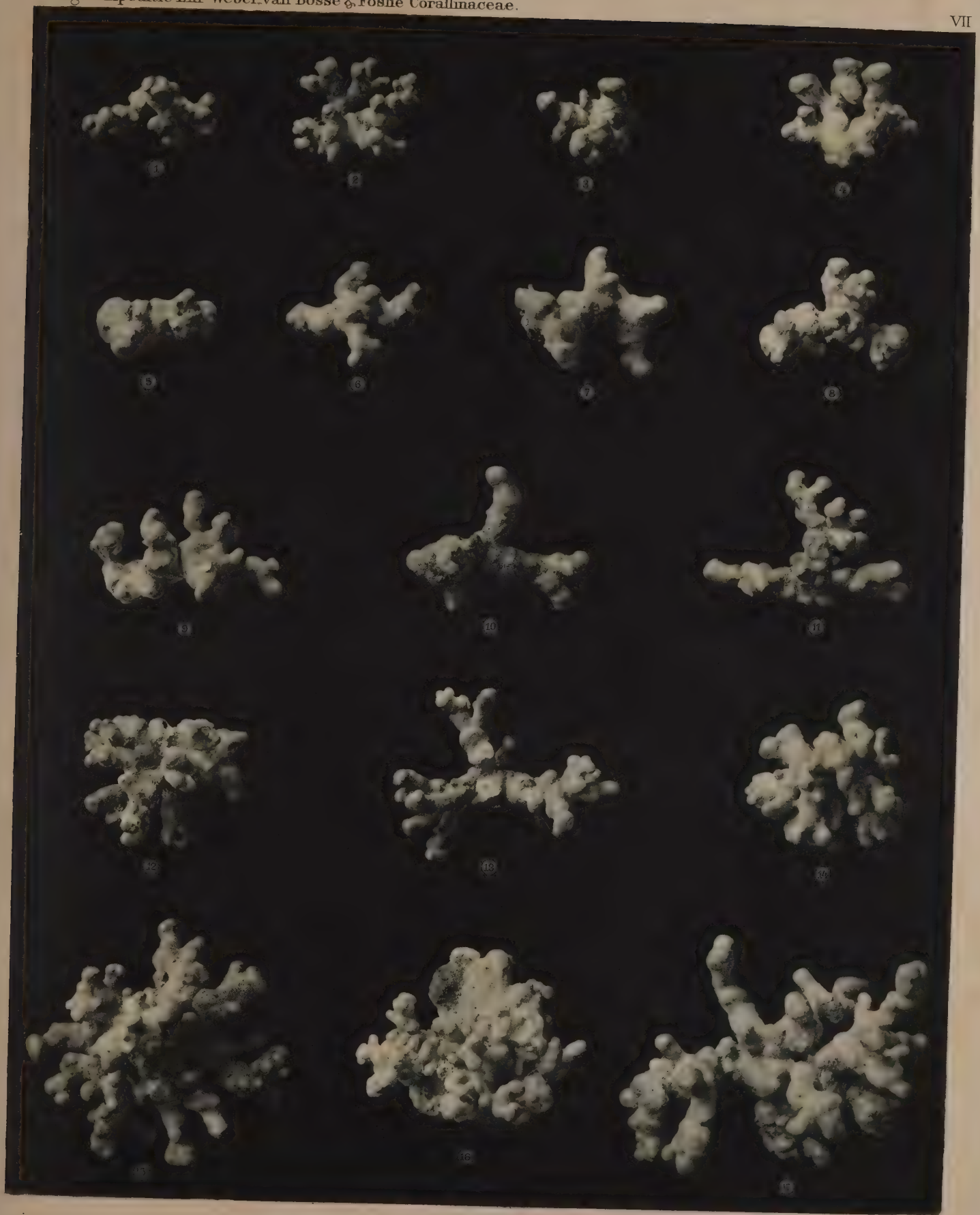

PLATE VIII.

Archaeolithothamnion timorense Fosl. Fig. 1—14.

Fig. 1, 3—6. Young and older specimens of the plant. Stat. 315.
Fig. 2. A young one. Stat. 282.
Fig. 7, 8, 13. Old specimens partly much burdened with foreign bodies. Stat. 277.
Fig. 9—12, 14. Similar ones partly burdened with small corals, Bryozoa and other foreign bodies. Stat. 315.

Archaeolithothamnion Schmidtii Fosl. Fig. 15—17.

Fig. 15. A part of the type specimen rather burdened with foreign bodies. Gulf of Siam.
Fig. 16. A specimen rather approaching to *A. timorense*. Stat. 96.
Fig. 17. An almost typically developed specimen. Stat. 169.

PLATE IX.

Goniolithon Fosliei (Heydr.) Fosl. Fig. 1—5.

Fig. 1. An authentic specimen from El Tor.
Fig. 2. An older and typical cystocarpic specimen attached to a coral. Stat. 78.
Fig. 3. A less regularly developed one. Stat. 91.
Fig. 4. An old specimen irregularly developed, with smaller or larger excrescences, at least in part owing to an irregular substratum, or numerous passages made by worms, around the orifices of which new formations of tissue are by and by heaped up. Zanzibar.
Fig. 5. A typical specimen attached to a piece of coral and partially covering *Peyssonnelia* sp., a part of which is visible to the right in the figure. Stat. 91.

Goniolithon myriocarpon Fosl. Fig. 6—7.

Fig. 6. Part of the type specimen attached to a shell. Massauah on the Red Sea.
Fig. 7. A sporangia-bearing specimen. Stat. 86.

Goniolithon megalocystum Fosl. Fig. 8—9.

Fig. 8. A fragmentary, sporangia-bearing specimen, representing the type of the species. Stat. 129.
Fig. 9. A supposed form of the species loosely covering Bryozoa, Squamariaceae, a young Goniolithon frutescens and other calcareous algae attached to a piece of coral. Stat. 93.

Goniolithon laccadivicum Fosl. Fig. 10—13.

Fig. 10. The type specimen from the Maldives.
Fig. 11. A rather young specimen attached to a coral. Stat. 311.
Fig. 12. An old one. Stat. 301.
Fig. 13. A not quite typical specimen (approaching certain forms of *G. frutescens*), accompanied by *Lithophyllum Okamurai* and *Goniolithon Reinboldi*, which are partly visible to the left and at the lowest part of the figure. Stat. 91.

PLATE X.

Goniolithon Reinboldi A. Web. et Fosl. Fig. 1—6.

Fig. 1. A young specimen of the plant. Stat. 282.
Fig. 2. An older specimen. Stat. 193.
Fig. 3—5. Old and typically developed specimens. Stat. resp. 282, 71, 91.
Fig. 6. A specimen approaching *Lithophyllum Okamurai* in habit. Stat. 91.

Goniolithon frutescens Fosl. f. *typica*. Fig. 7—9.

Fig. 7—9. Rather delicate specimens of the form; fig. 9 seen from the side. Stat. 261.

Goniolithon frutescens Fosl. f. *congesta*. Fig. 10—11.

Fig. 10—11. Specimens of this form not quite typically developed. Stat. 220.

Goniolithon frutescens Fosl. f. *subtilis*. Fig. 12—13.

Fig. 12—13. Typical specimens of the form. Stat. 225.

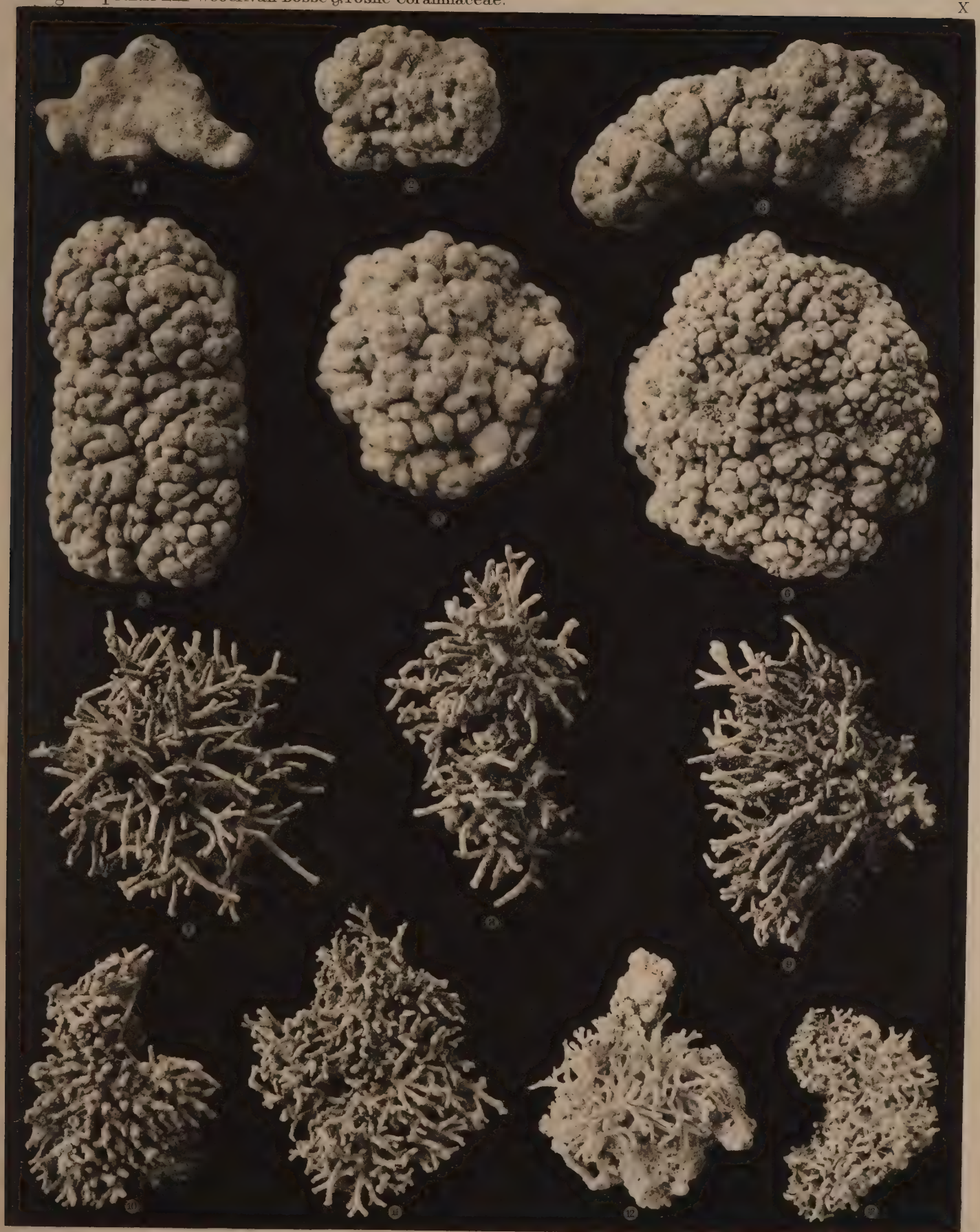

PLATE XI.

Lithophyllum Yendoi Fosl. Fig. 1—4.

Fig. 1. The type specimen from the Pacific coast of Japan (Shimoda harbour).
Fig. 2. The plant attached to a kind of rather hard wood. Stat. 155.
Fig. 3. Typically developed specimen from stat. 193.
Fig. 4. Specimens attached to a piece of Mangrove *(Rhizophora)*. Stat. 86.

Lithophyllum oncodes Heydr. Fig. 5—10.

Fig. 5. Part of a typically developed specimen from Funafuti, in the upper corner confluent with a piece of coral.
Fig. 6. A fragment of the latter specimen, seen from the side; the dark points in the surface of fracture are passages made by worms.
Fig. 7. An irregularly developed specimen attached to a conch. Stat. 225.
Fig. 8. A similar one forming small cap-shaped crusts on excrescences of a coral, in company with other algae and sponges. Stat. 91.
Fig. 9. A rather well developed specimen attached to a coral. Stat. 181.
Fig. 10. An old and partly waterworn specimen surrounding a piece of coral. Stat. 225.

Lithophyllum Okamurai Fosl. Fig. 11—19.

Fig. 11. The type specimen of the species. Pacific coast of Japan.
Fig. 12. The type specimen of f. *angulata*. Pacific coast of Japan.
Fig. 13. The type specimen of f. *japonica*. Pacific coast of Japan.
Fig. 14, 15. Typically developed specimens of the latter form. Stat. 91.
Fig. 16. A specimen anastomosing with *Goniolithon Reinboldi*. Some of the branches of the latter species are marked with a cross in the figure. Stat. 91.
Fig. 17. A specimen partly dead and waterworn, anastomosing with *Archaeolithothamnion erythraeum*. Stat. 93.
Fig. 18, 19. Specimens showing rather delicate branches. Stat. 303.

PLATE XII.

Lithophyllum Bamleri Heydr. Fig. 1.

Fig. 1. A rather well developed specimen of the plant. Stat. 282.

Lithophyllum moluccense Fosl. f. *typica*. Fig. 2—4, 6, 8.

Fig. 2. A detached part of a specimen continuing its growth freely at the bottom, with effaced surface of fracture. Stat. 91.
Fig. 3. A young specimen attached to a coral. Stat. 91.
Fig. 4. A somewhat older one. Stat. 129.
Fig. 6. An old specimen rather burdened with extraneous objects. Stat. 193.
Fig. 8. A specimen attached to a piece of dead coral. Stat. 93.

Lithophyllum moluccense Fosl. f. *flabelliformis*. Fig. 5, 9, 10.

Fig. 5. A rather young specimen. Stat. 91.
Fig. 9. A detached specimen. Stat. 91.
Fig. 10. An attached one. Stat. 193.

Lithophyllum moluccense Fosl. f. *torquescens*. Fig. 11.

Fig. 11. The type specimen of the form, probably from the Mauritius.

Lithophyllum moluccense Fosl. f. *pygmaea* (Heydr.) Fosl. Fig. 7, 12, 13.

Fig. 7. Specimen of the form seen from the side. Stat. 220.
Fig. 12. An old specimen intermingled with other and filiform algae. Stat. 220.
Fig. 13. A similar one attached to a coral. Stat. 220.

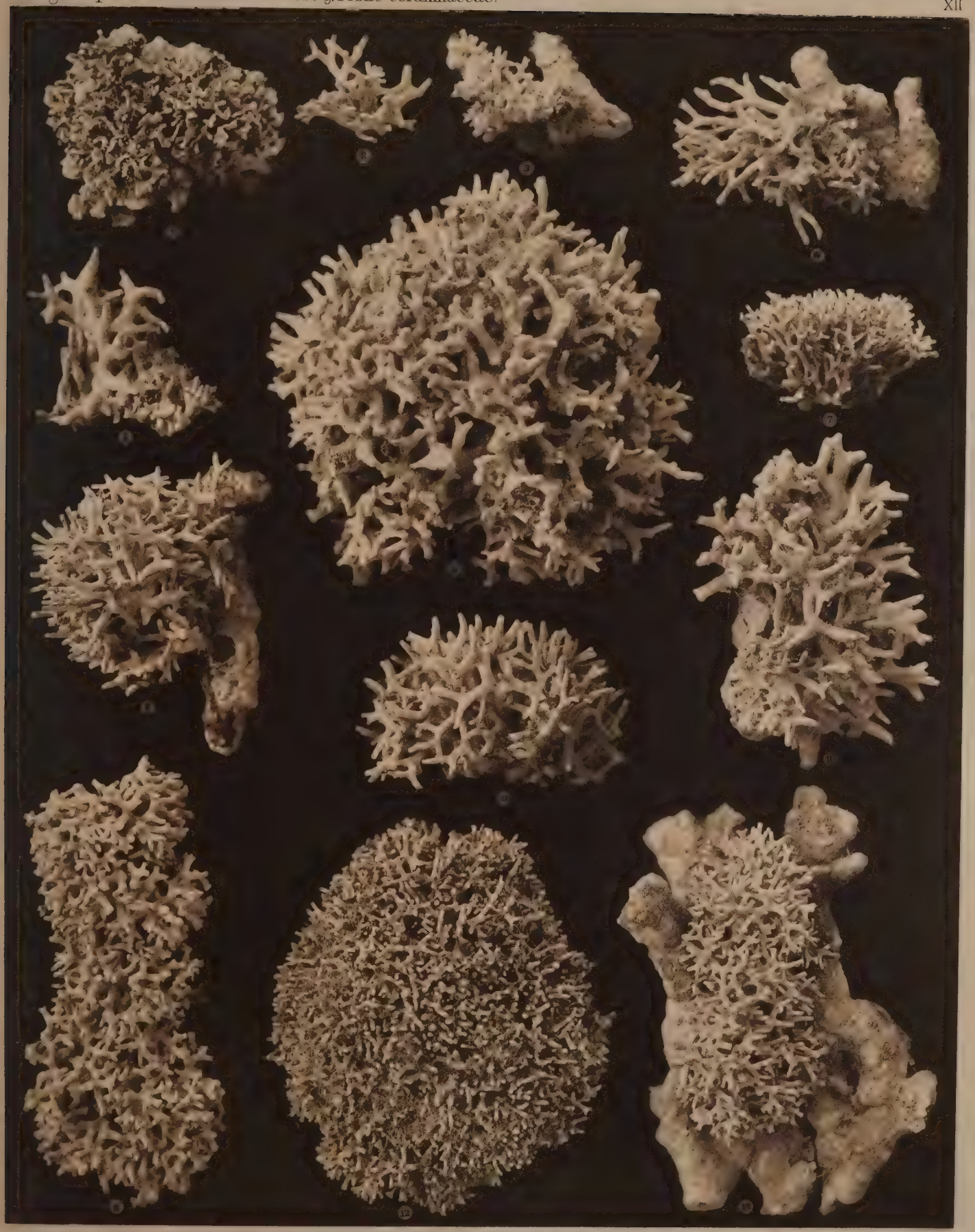

PLATE XIII.

Mastophora macrocarpa Mont.

Fig. 1—3. Young specimens partly covering other algae. Stat. 58.
Fig. 4. A similar one attached to *Carpopeltis*. Stat. 279.
Fig. 5—6. Older specimens. Birakéké, Celebes.
Fig. 7. A similar one. Stat. 129.
Fig. 8. An old one, the greater part of which has apparently grown freely. Stat. 115.
Fig. 9. A specimen attached to different algae. Den Brill near Macassar.
Fig. 10. An old specimen, the greater part of which has apparently grown freely. Stat. 125.
Fig. 11. A similar one. Stat. 149.
Fig. 12. A similar one. Stat. 231.

PLATE XIV.

Fig. 1—11. *Amphiroa foliacea* Lamx.
Fig. 1. Creeping frond.
Fig. 2—8. Erect fronds with broad and narrow and even cylindrical joints. The figures 1 and 4 show the extremes observed in *A. foliacea*. All these figures are drawn in nat. size.
Fig. 9. Part of winged frond. $^{30}/_{1}$.
Fig. 10. Young top of creeping frond. $^{30}/_{1}$.
Fig. 11. Node between the joints. The shaded part indicates the node. $^{30}/_{1}$.
Fig. 12. *Amphiroa fragilissima* Lamx. f. *cyathifera* nat. size.
Fig. 13. Two nodes of *Amphiroa ephedraea* Lamk. $^{30}/_{1}$.
Fig. 14—17. *Amphiroa Bowerbankii* Harv.
Fig. 14. Upperside of frond. nat. size.
Fig. 15. Underside of frond. nat. size.
Fig. 16. Section through the node with little dots of calcareous tissue growing out of the node. $^{30}/_{1}$.
Fig. 17. Node seen from above; one little dot of calcareous tissue is indicated by the darkest shade. $^{30}/_{1}$.
Fig. 18—19. *Amphiroa Beauvoissii* (Lamx.) Born. (*A. exilis* Harv.).
Fig. 18. A. specimen from Naples. $^{30}/_{1}$.
Fig. 19. A specimen from Durban. $^{30}/_{1}$.

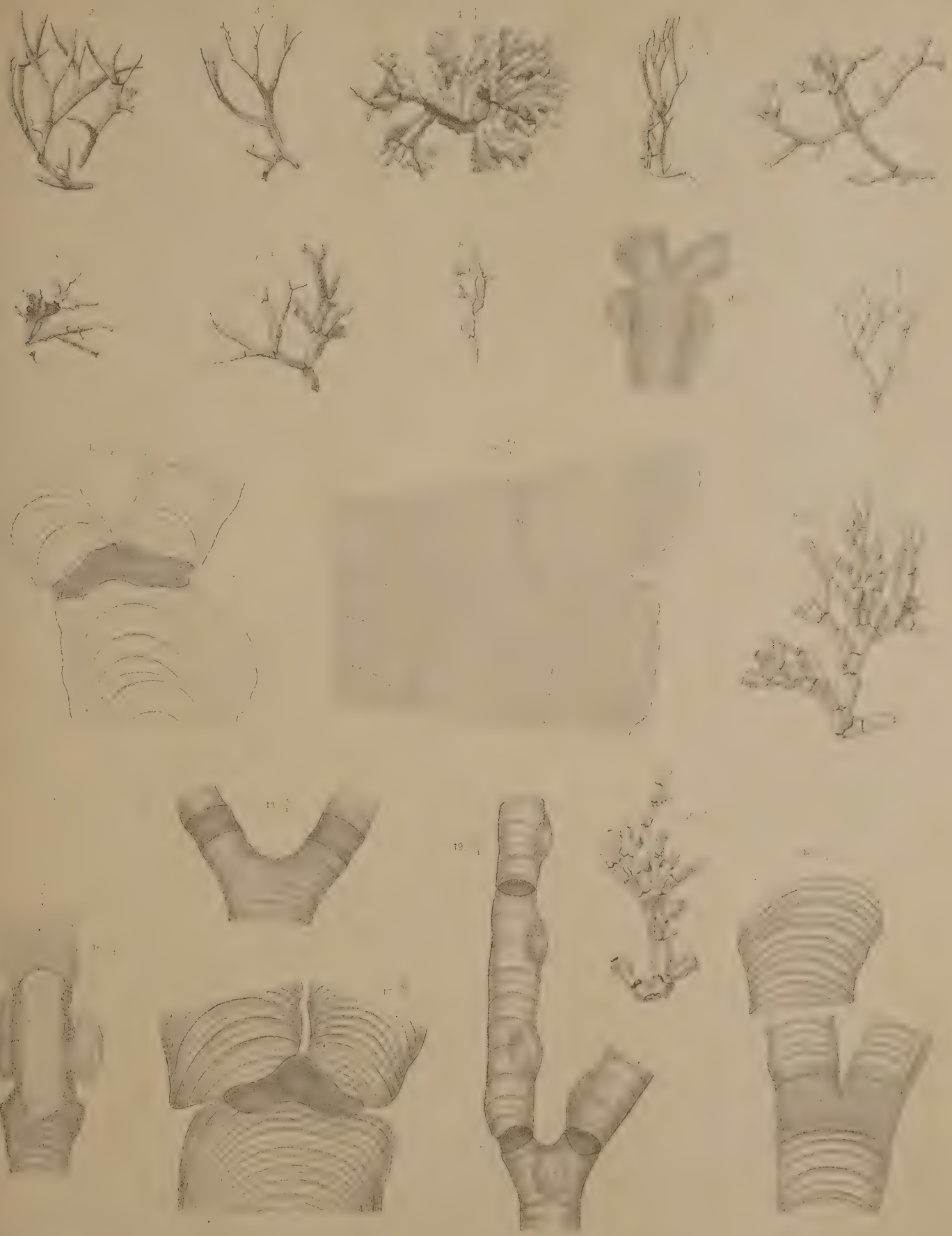

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PLATE XV.

Fig. 1—7. *Amphiroa crassa* Lamx.
Fig. 1, 4. f. *typica*. nat. size.
Fig. 2. f. *Godeffroyi*. nat. size.
Fig. 3. f. *minuta*. nat. size.
Fig. 5. Node between two joints. The cortical layer has split all around the node. $^{30}/_{1}$.
Fig. 6. Node entirely surrounded by the calcified cortical layer. $^{30}/_{1}$.
Fig. 7. Cells of central strand, showing the small pores in the longitudinal walls. $^{405}/_{1}$.
Fig. 8. Node of *Arthrocardia cretacea* (Post. et Rupr.). $^{47}/_{1}$.
Fig. 9. Node and branches of *Metagoniolithon stelligerum*. The branches spring from the node. $^{30}/_{1}$.
Fig. 10. Section through node of *Metagoniolithon graniferum*. $^{95}/_{1}$.
Fig. 11. Longitudinal section through apex of branch of *Metagoniolithon charoides*. The small cells indicate the future node. $^{95}/_{1}$.
Fig. 12. Young top of *Metagoniolithon graniferum* showing the thick mucilaginous layer covering the top; in this layer slight striae were visible. $^{47}/_{1}$.
Fig. 13. *Metagoniolithon stelligerum*. Node with three branches. $^{47}/_{1}$.
Fig. 14. Cells of central strand of *Metagoniolithon*, showing the big, thin places in the longitudinal walls. $^{405}/_{1}$.
Fig. 15. *Lithothrix aspergillum* Gray. Longitudinal section through top of frond. $^{47}/_{1}$.
Fig. 16—17. *Litharthron (Amphiroa) australis*.
Fig. 16. Joints of young fronds. $^{3}/_{1}$.
Fig. 17. Longitudinal section through frond. $^{175}/_{1}$.

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PLATE XVI.

Fig. 1, 2, 5. *Amphiroa fragilissima* Lamx.
- Fig. 1. Large specimen from Banda. nat. size.
- Fig. 2. Young node which begins to develop itself. $^{30}/_{1}$.
- Fig. 5. Full-grown node. $^{15}/_{1}$.

Fig. 3, 4. *Amphiroa anastomosans* n. sp.
- Fig. 3. Fronds in nat. size.
- Fig. 4. Fronds enlarged $^{30}/_{1}$.

Fig. 6—8. *Amphiroa anceps* (Lamk.) Dec.
- Fig. 6. Frond nat. size.
- Fig. 7. Young node $^{30}/_{1}$.
- Fig. 8. Older node quite developed $^{30}/_{1}$.

Fig. 9—12. *Amphiroa canaliculata* v. Mart.
- Fig. 9. Growing top of frond $^{10}/_{1}$.
- Fig. 10. Frond upperside. nat. size.
- Fig. 11. Frond underside. nat. size.
- Fig. 12. Three transversal sections through frond. nat. size.

Fig. 13. *Amphiroa rigida* f. *divaricata*. nat. size.

Fig. 14. Longitudinal section through joint and node of *Amphiroa verrucosa* Kütz. (*A. cryptarthrodia* Zan.). $^{70}/_{1}$.

Fig. 15. *Corallina officinalis* Linn. $^{22}/_{1}$.

Fig. 16. *Jania rubens* Linn. Longitudinal section through joint and node. The horizontal lines marking the rows of cells are too straight. They ought to have been more like what one sees in fig. 18. $^{70}/_{1}$.

Fig. 17. Part of a section of a fossil *Amphiroa* spec. *(fragilissima?)* from Totok Celebes. $^{75}/_{1}$.

Fig. 18. Part of a section of a fossil *Jania* from the mountain Nona at Ambon. $^{175}/_{1}$.

Fig. 19. Longitudinal section through a type specimen of *Amphiroa fragilissima* Lamx. $^{87}/_{1}$.

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